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16. ABSTRACT

The overall objective of this pilot study was to develop and evaluate methods to determine the effect of quality of recreational waters on the health of persons bathing in those waters. There is little scientific evidence upon which to base water quality standards for the safety of persons using recreational waters for primary contact.

Results of this study indicated that it is possible to recruit families and follow them via telephone interviews over a three-week period with low attrition. A promotional letter used in conjunction with this study had no positive effect in reducing the attrition rate.

The concentrations of the water variables were found to be significantly different ($p<0.05$) depending on the time of day and day of weekend that they were collected. On the whole, there were no significant differences ($p>0.05$) in the water variables when measured at five different water sampling locations at each beach.

This pilot study does not provide any information about the relationship of health and recreational water quality. However, a subsequent study can now be conducted to survey a large population at beaches of differing water quality to evaluate the relationship of water quality and health.

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RECREATIONAL WATER QUALITY AND HEALTH

by

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FOREWORD

The U. S. Environmental Protection Agency was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our national environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The primary mission of the Health Effects Research Laboratory in Cincinnati (HERL) is to provide a sound health effects data base in support of the regulatory activities of the EPA. To this end, HERL conducts a research program to identify, characterize, and quantitate harmful effects of pollutants that may result from exposure to chemical, physical, or biological agents found in the environment. In addition to the valuable health information generated by these activities, new research techniques and methods are being developed that contribute to a better understanding of human biochemical and physiological functions, and how these functions are altered by low-level insults.

This report provides information on the pretest or pilot test of microbiological methods and the epidemiological instrument used to assess the relationship between a measurable microbiological entity and swimmers' health. The results of this study indicated epidemiological information can be obtained over a three week period following the initial interview with relatively low attrition. There were no significant differences in water variables measured at five sampling sites each at the experimental and control beaches. Water variable concentrations were found to be significantly different ($p<0.5$) depending on the time of day, day of weekend and weekend that they were collected. This pilot study indicates that an evaluation of the relationship between recreational water quality and bathers' health could be performed, provided the survey population is large enough.

The Agency pursued two parallel projects, one for fresh waters and another for marine waters, but the marine project started earlier and was more actively supported. The marine studies have been completed and they lead to development of criteria based on a dose response relationship; Health Effects Quality Criteria for Marine Recreational Waters, EPA-600/1-80-031 (September 1980). The protocol developed in the marine project has now been applied to two fresh water beach studies. The study reported here will provide background for future studies but these other developments have passed on to provide information for establishment of criteria for sewage treatment and wastewater discharges affecting recreational beaches and waters.

Dr. James B. Lucas, Acting Director
Health Effects Research Laboratory

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ABSTRACT

The overall objective of this pilot study was to develop and evaluate methods to determine the effect of quality of recreational waters on the health of persons bathing in those waters. There is little scientific evidence upon which to base water quality standards for the safety of persons using recreational waters for primary contact.

This pilot study was designed to develop: (1) sampling and recruiting methodology of families attending freshwater beaches; (2) survey instruments for telephone interviews to obtain demographic and socioeconomic information, and the collection of prospective data regarding health status of family members; and (3) the sampling design for the collection of certain water quality variables in order to best relate the effect of the quality of recreational waters to the health of persons bathing in those waters.

Results of this study indicated that it is possible to recruit and follow families via telephone interviews over a three-week period with low attrition rates. A promotional letter used in conjunction with recruitment had no positive effect in reducing the attrition rate.

The demographic characteristics of bathers and nonbathers at the two study beaches were generally similar. Families at the beach with poor water quality had a slightly lower socioeconomic status (SES) than families at the beach having good water quality. The majority of participants in this study were bathers who generally immersed their whole body.

The concentrations of the water variables were found to be significantly different ($p<0.05$) depending on the time of day and day of weekend that they were collected. On the whole, there were no significant differences ($p>0.05$) in the water variables when measured at five different water sampling locations at each beach.

This pilot study does not provide any information about the relationship of health and recreational water quality. However, a subsequent study can now be conducted to survey a large population at beaches of differing water quality to evaluate the relationship of water quality and health.

This report was submitted in fulfillment of Grant No. R-804569 by the University of Illinois, School of Public Health, Chicago, under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period of September 15, 1976 to May 14, 1979.

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SECTION 1

INTRODUCTION

Pollution of bathing beach waters has been a matter of concern to many public health officials because of the potential for contacting many diseases while bathing in these waters. Such life-threating diseases as typhoid fever, poliomyelitis infectious hepatitis, viral gastroenteritis, tuberculosis, histoplasmosis, leptospirosis, and primary amebic meningoencephalitis can be contacted through swimming in polluted water. In addition, various upper respiratory tract infections and diseases of the eye, ear, nose, and throat have also been observed to occur from primary contact with polluted water.

A major problem has been determining whether a beach is "safe" for swimming. The most frequently used indicator presently being used for this determination is the fecal coliform. However, no epidemiological study has ever adequately assessed whether communicable diseases may be acquired from primary contact with water that contains a particular fecal coliform concentration. An examination of the literature indicates that a higher overall illness incidence may be expected among bathers than nonbathers irrespective of the water quality.

Since all of the epidemiological studies conducted in the past to assess the incidence of illness from bathing in polluted water have had design problems, this pilot study has examined a wide variety of variables at two beaches on Lake Erie in Ohio to better assess the design to be used for a large scale survey. In this pilot study, particular emphasis has been given to development and administration of a health questionnaire; to characteristics of the study populations; to the ability to follow a study population for a three-week period via telephone interviews; to water sampling design; and to various microbiological, physical, and chemical parameters that may be used to associate water quality and health.

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SECTION 2

CONCLUSIONS

In this pilot study, approximately 70% of the 83 families recruited at the poor water quality beach (Edgewater Beach) remained in the study for the three-week follow-up period, while approximately 85% of the 94 families recruited at the good water quality beach (Headlands Beach) remained in the study for the entire follow-up period. A promotional letter had no substantive effect on the attrition rate.

The demographic characteristics of the bathers and nonbathers are generally similar at these two beaches. Approximately 70% of the recruited population was white. Families at the poor water quality beach had a slightly lower socioeconomic status (SES) than those at the higher water quality beach.

Approximately 60% of the participants were bathers at Edgewater Beach, and approximately 88% were bathers at Headlands Beach. Of those individuals bathing, approximately 60% at Edgewater Beach and approximately 80% at Headlands Beach had total body immersion in the water. Participants went swimming less frequently as the study progressed.

Since attrition continued over the three-week follow-up period, illness rates need to be based on person-days of participation in the study rather than on number of persons participating. This pilot study did not provide conclusions about the health effects of bathing in a poor quality water. A study of a large number of bathers and nonbathers at beaches of varying water quality, based on the design developed in this pilot study, is needed to address the question of health effects and water quality. The design would include an analysis of health data for those individuals on the day of recruitment.

The physical and chemical water variables were observed to be quite similar between the two beaches, while Edgewater Beach had considerably higher concentrations of several microbiological variables than Headlands Beach. As a consequence, only microbiological analyses need to be conducted for a subsequent study. Since the microbiological variables were found to be significantly different ($p<0.05$) according to time of day and day of weekend of water sampling, it is important to relate the specific time-day of weekend that a bather entered the water in order to relate the health effects to these exposure variables.

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SECTION 3

RECOMMENDATIONS

For future beach studies that would use the methodology developed in this pilot study, the following changes are recommended:

1. Attrition would be reduced in future beach studies by having the survey workers go directly to the homes of those families who do not have home telephones.

2. Families should be asked to contact the survey workers, as they leave the beach, to state individually their bathing experience relative to amount of body exposure to the water and length of time of that exposure.

3. Information should be gathered about the health status of bathers and nonbathers on the day of recruitment.

4. A two-week follow-up period is minimally required so that long incubation periods of various infectious agents like viruses can be included in the evaluation.

5. Quality of recreational water can be adequately monitored by sampling the water for microbiological variables at one central location in the bathing area instead of the five locations used in this study, as long as time of day and day of weekend are considered.

6. A large scale study should not be conducted at Edgewater Beach because it is estimated that less than 250 families use this beach during the summer swimming season. It was estimated from this pilot study that approximately 850 families would have to be recruited to be able to detect a significant difference between the two beaches' illness rates.

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SECTION 4

BACKGROUND INFORMATION

DISEASES ASSOCIATED WITH BATHING AND SWIMMING

Pollution of bathing waters has been a concern to public health officials for some time because of the potential for transmission of infectious diseases. The Committee on Bathing Places, Sanitary Engineering Section, American Public Health Association, in 1922, concluded that contaminated bathing water may transmit infectious agents to bathers (1). Little definitive information concerning illnesses attributable to bathing places could be found by that committee (now designated as the Joint Committee on Bathing Places on the Health Engineering Section of The American Public Health Association and the Conference of State Sanitary Engineers) in the 30's, 40's, and 50's (2-4). The 1936 report by the committee stated that bathing places probably are not a major public health problem, but should be kept under surveillance to make sure proper sanitary control is maintained at bathing places. The 1949 and 1951 reports suggested that contaminated bathing waters may be related to cases of sleeping sickness, sinus infections, intestinal upsets, eye inflammation, "swimmers itch," ear infections, and leptospirosis.

Although there is no definitive evidence that a relationship exists between water quality and transmission of infectious disease among bathers, there is presumptive evidence which suggests such a relationship. For example, several outbreaks of human leptospirosis have been associated with recreational waters (5-8). A major source of exposure is bathing or swimming in waters contaminated by cattle waste. Infection results from the leptospira entering the body through breaks in the skin or mucous membranes.

Another disease, chronic skin granulomas of the elbow or knee, was found in children and some adults who had a history of swimming in salt water in Mobile, Alabama (9). Lesions generally resulted from sustaining injuries to the knee or elbow allowing *Mycobacterium marinum* to enter the wound.

An epidemic of shigellosis in Dubuque, Iowa, was traced to swimming in the Mississippi River (10). Both epidemiologic and laboratory data implicated swimming in the River as the predominat mode of contacting *Shigella sonnei* in the outbreak. Epidemiologically, 32 of the 45 reported cases were associated with swimming; 22 patients had been swimming in the river within three days before becoming ill, eight others had close contact with an ill individual, and two had swum in the river for a period of four and 10 days, respectively, before becoming ill. Comparison of the first case of shigella in each affected family (29 families) against neighborhood controls showed

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a significant association between swimming in the River and illness (P<.0001). Shigella sonnei isolates were recovered from both the patients and the River. The isolate from the River was found after the outbreak of shigellosis.

A much more serious and often fatal disease, primary amebic meningoencephalitis, has been associated with swimming (11-19). This disease results from contact with a free-living soil and water amoeba of the Naegleria group. The portal of entry, in most cases, is the nasal mucosa. It is suspected that this normally harmless ameba becomes a deadly pathogen when its cysts are introduced into warm waters with high bacterial concentrations (20). The bacteria are capable of transforming the cysts into the pathogenic forms of this otherwise innocuous ameba.

Another disease that might be associated with swimming is hepatitis. Although there are many reports of hepatitis epidemics in which drinking water is implicated as the vehicle of transmission, the possibility exists that swimmers and bathers could also contact the disease. A case in point concerns 14 of 30 members of a boy scout troop who developed viral hepatitis after camping on an island in a nearby lake recreation area (21). In those people who became ill, a statistically significant difference (P=0.007, Fischer's Exact Test) was found between those who accidently drank the lake water from 5-gallon water cans and/or admittedly swallowed lake water while swimming. Although it was not possible to demonstrate the presence of hepatitis virus in the lake water for lack of laboratory methods, this water was found to have fecal contamination. However, a different study at a summer camp in Vermont isolated coxsackie virus B5 from swimming water during an epidemic outbreak of this disease (22).

Up to now, the above-mentioned episodes representing the more serious illnesses that may be associated with recreational bathing have been discussed. However, diseases of the eyes, ears, nose and throat, gastrointestinal tract, and skin are additional illnesses occurring at relatively higher incidence rates among bathers than nonbathers. These illnesses cannot always be associated with poor recreational water quality (23-28).

EPIDEMIOLOGICAL STUDIES OF BATHING WATER QUALITY AND HEALTH

There have been few epidemiological studies that have attempted to assess incidence of illness with bathing in waters with fecal contamination. Three epidemiological studies were conducted by the Public Health Service in the 1950's with the major objective of determining differences in illness incidence from swimming in waters containing various degrees of bacterial pollution (23,24,25,27).

The first study (23,25), conducted on three selected days at a Lake Michigan Beach in Chicago, Illinois, when the mean total coliform concentration of the water was 2,300 per 100 ml of sample, showed an increase in the incidence of eye, ear, nose, throat, and gastrointestinal tract infections. These high infection rates were not noted at a control beach over the total season, but, since only three days were used for the comparisons the association was hardly conclusive.

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The second study (24,25) was done at the Ohio River at Dayton, Kentucky. Gastrointestinal illnesses were found to be higher in bathers swimming in the Ohio River where the median coliform count was 2,700/100 ml than in bathers swimming in a public pool. However, the overall incidence of gastrointestinal disturbance was low and the comparative incidence of all illnesses reported was higher for swimmers at the pool than at the River.

In the third study (25), at salt water beaches on Long Island Sound in New York, no relationship between illness and water quality was found. The approach used here was to compare the rate of illness in bathers at either two beaches, or one beach and a swimming pool, that were substantially different in water quality. One major criticism of these studies was that bathing was not defined. As a consequence, individuals who never had upper body orifices in direct contact with water could have been defined as bathers. In addition, the control population did not go to the beaches, so that the two populations may not have been comparable with regard to risk of exposure.

Another study, conducted in sewage-polluted sea water in England, concluded that sea water carries only a negligible risk to health. Moore (29) had examined retrospectively the bathing experience of individuals known to have had poliomyelitis and enteric fever and compared them with the bathing history of a matched control group of health persons. Although the procedure is sound epidemiologically, the information collected was inconclusive because of the problems in documenting bathing experience and quality of water when the exposure presumably occurred long before the disease was clinically evident.

A study by Cabelli et al. (30,31) conducted in marine waters in New York suggested that there may be a higher incidence of gastrointestinal illness among bathers at a "barely acceptable" beach compared to those bathing at a "relatively unpolluted" beach. However, no conclusions could be drawn because this was a pretest study with too few participants to make statistical analyses. An update of this study (32) reported that the rate of gastrointestinal symptoms among swimmers relative to nonswimmers was statistically higher (P=0.05) at the "barely acceptable" beach, but not at the "relatively unpolluted" beach. However, the rate of swimmer gastrointestinal illness was not substantially different between the two beaches.

In summary, all of the above epidemiological studies have been inconclusive. A cause-and-effect relationship between bacterial levels in recreational waters and illness has not yet been convincingly demonstrated.

WATER QUALITY STANDARDS FOR BATHING AND SWIMMING

Since no physical, chemical, or biological parameter has been established which can be used to assess water safety for bathing, there are tremendous variations in water quality standards used for swimming. In 1949, all U.S. Bathing Water Quality Standards were based on the total coliform counts ranging from 50 to 2,400 coliforms/100 ml of sample (33). This disparity between total coliform counts for these standards becomes even more prominent when international standards are compared. For instance, England and Wales use a standard of 10,000 coliforms/100 ml. Japan uses 50,000 coliforms/100 ml while Australia and South Africa have no standards (34). There are numerous documents showing the great variability in total coliform counts used as standards for bathing water quality (26,35-38).

Total coliform bacteria have generally been replaced by fecal coliform bacteria as an indicator of bathing water quality. The reason for this change was that total coliform bacteria include coliforms of both fecal and nonfecal (naturally occurring) origin. The nonfecal organisms are of limited sanitary significance since they are not pathogens for men or animals and are capable of excessive growth in fecal waste.

Although fecal coliform bacteria in the environment are indicators of animal fecal contamination (39), the fecal coliform counts employed in the U.S. and its territories for bathing water quality standards are variable. For instance, fecal coliform standards for beaches vary from 70 to 1,000/100 ml of sample in the U.S. (40). The most common count used for bathing waters is 200 fecal coliforms/100 ml sample and is based on a total coliform to fecal coliform ratio of 5:1 (41). There is no scientific justification that recreational waters containing a total coliform count of 1,000 with 20 percent fecal coliforms is safe for swimming. Regardless of the scientific basis, in 1968 the Committee on Water Quality Criteria (42) recommended that "...the fecal coliform content of recreation waters shall not exceed a log mean of 200/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml." Geldreich (39) supported the above standard when he stated that fecal coliforms have been assessed and reassessed as indicators of pollution in recreational waters and felt that 200 fecal coliforms/100 ml for bathing beaches is both realistic and consistent with laboratory and field investigations.

Several bacteriological surveys of recreational waters have been conducted with the primary objective of determining water quality changes and safety for use (43-47). All of these studies were successful in demonstrating fecal contamination at these various recreational waters at one time or another. However, they were not able to establish a critical minimum total coliform, fecal coliform, fecal streptococci, or salmonella concentration that would be safe for human contact.

Although most states presently have bacteriological standards and conduct bacteriological surveys for water quality, there is no sound epidemiological or laboratory evidence that communicable diseases may be acquired by contact with contaminated water (48). This was also the opinion of the Committee on Water Quality Criteria in 1972, which states that "no specific recommendation is made concerning the presence or concentration of microorganisms in bathing water because of the paucity of valid epidemiological data." (49)

It has been shown throughout this background section that many different types of bathing-related illnesses may be acquired through contact with or ingestion of recreational water. Therefore, it is unlikely that one bacterial indicator such as fecal coliforms will sentinel all health hazards related to recreational waters. Consequently, indicator organisms other than or in addition to fecal coliforms have been suggested for bathing standards. Such organisms as Staphylococci (50), Streptococci and Clostridia (51), and *Pseudomonas aeruginosa* (52,53) are but a few of the possible indicators of health hazards for recreational waters.

Although bacteriological parameters have generally been used to determine whether or not a water is "safe" for swimming, the City of Milwaukee, Wisconsin, has developed a pollution prediction formula for determining that a beach should be closed (54). This formula is primarily based on rainfall; the amount of rain is directly related to the number of hours or days that Milwaukee beaches will be closed. Since this formula is based on Milwaukee's specific geography, physical characteristics, hydraulics, and point sources of pollution, it is not possible to extend this formula to any other locales. Also, this formula only predicts when the water quality will be at its worst and does not guarantee illness-free bathing.

A final point for consideration is that there is no evidence yet to show that bacteriologically clean water may not, on occasion, contain agents (such as animal viruses) that are potential health hazards. Although laboratory technology is not yet developed to explore all possibilities, sound epidemiological studies could be designed to assess such associations.

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SECTION 5

PROJECT DESIGN AND METHODOLOGY

This is a pilot project designed to examine epidemiologically the morbidity rates of illness associated with bathing beaches that exceed the standard for fecal coliform concentrations. Since there are multiple variables and unknowns that can be considered in a study of beach populations and for which there are no established methodologies, this pilot study was essential.

MORBIDITY METHODOLOGY

Beach Selection

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Two beaches in the Cleveland, Ohio, metropolitan area on Lake Erie were chosen for the initial pilot study. One beach, Edgewater, is located in the City of Cleveland on the west side. It has 250 meters of shoreline and is situated near two major point sources of organic and inorganic pollution that contribute high concentrations of fecal coliforms at the beach. One source of the pollution comes from the Westerly Wastewater Treatment Plant located approximately 1600 meters east of the beach. At the time of this study, the influent at the treatment plant was only receiving primary treatment. It is presently being modified to include advance wastewater treatment. The second point source of fecal coliform contamination is from two storm sewers located approximately 300 and 3000 meters west of the beach. The monthly geometric mean fecal coliform concentrations at Edgewater Beach consistently exceed the Ohio Department of Health Standard of 200 coliforms/100 ml sample based on not less than five samples per month. Even though the Cleveland Department of Health has posted Edgewater Beach as "unsafe for swimming," people still use the beach for bathing. The Cleveland Department of Health approved the use of Edgewater Beach for this study.

The other beach utilized in this pilot study, Headlands State Park, is located approximately 40 kilometers east of the City of Cleveland near Mentor, Ohio. This beach, with its 600 meters of shoreline, has monthly geometric mean fecal coliform concentrations well below the state standard. No wastewater treatment plants, storm sewers, or other point sources of fecal coliforms were found in the vicinity of this beach. In fact, a water treatment plant is located approximately 100 meters west of the beach. Approval for the use of Headlands State Park was given by the Ohio Department of Natural Resources.

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Family Selection

After the two beaches were selected, 100 families from each beach were systematically selected to voluntarily participate in the study. Since the 100 families were to be selected over three weekends in July, 1977, (July 16-17; 23-24; and 30-31), it was decided to recruit families equally over the three weekends. Therefore, the sampling scheme was to be conducted as follows: 17 respondent families would be contacted at each beach for each of the six days of the recruitment period. Starting at 10:00 a.m., the first automobile to enter the beach parking lot with a family would be contacted to determine eligibility and willingness to participate. To be eligible, the passengers in the car must be residents of the Cleveland metropolitan area (e.g., available by telephone in the City of Cleveland without a toll charge) and be a family with children. Also, if more than one family was in the car, the respondent family was the driver and his family. All eligible families were given a brief explanation of the study and told of the importance of their participation. Part of the explanation included telling the families that they would have to be willing to be called on the telephone four times over the next three weeks and to answer questions about their health and swimming experience. No more than two eligible, willing families would be contacted during each half-hour period. By 2:30 p.m., the sample for that day would be complete.

Once the above families were recruited at the beach, name, age, sex, race, relationship, telephone number, and address were recorded for each member by direct questioning or observation (Appendix A-Recruitment). A convenient time was worked out for the initial follow-up phone call. In addition to a verbal explanation of the study, half of the recruited families received a letter reaffirming the verbal comments (Appendix B). The reason only half of the participants received this letter was to determine whether those respondents who received it cooperated over the three-week follow-up better than those who did not receive the letter.

Health Survey

After the recruitment process was completed for a particular day, a follow-up phone call was made that evening (or the next day) to determine the respondents' swimming experience during that day and/or any other time during the last week (Appendix A-first follow-up phone call). Such information as amount of body immersion in the water (bathers), duration of water contact, and total time spent at the beach was obtained. Although bathers were defined as having primary contact with the recreational water at the beach, they were subdivided into those having total body immersion or immersion to the shoulders, waist, or knees. Nonbathers were included in this pilot study in an effort to establish whether they would serve as a control group for bathers. Nonbathers were individuals at the beach who had no contact with the water. In addition, questions were asked regarding incidence of acute illnesses related primarily to the respiratory tract, the gastrointestinal tract, the integument, the ears, and the eyes. One adult respondent answered all of the above questions for each member of his/her family. An attempt was made to see if the respondent conferred with the household members for reliability of proxy responses.

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The second follow-up phone call was conducted seven or eight days after the initial contact (Appendix A-second follow-up phone call). The same information obtained from the previous follow-up phone call was obtained with the exception that this information pertained only to the seven or eight day period after the initial contact and did not ask about amount of body immersion, duration of water contact, and total times at beach. In addition, socioeconomic status of respondents was obtained by asking questions pertaining to education and employment.

The third follow-up phone call was made two weeks after recruitment. (Appendix A-third follow-up phone call). Information obtained from this telephone call pertained only to the time period between the second and third follow-up phone calls. The same information was gathered as in the second follow-up phone call except for the socioeconomic status information. New information collected regarded chronic health problems primarily in relation to the integument, the gastrointestinal tract, and the respiratory tract.

The fourth and last follow-up contact (Appendix A-fourth follow-up phone call) asked exactly the same questions as the third follow-up telephone call with the exception of questions related to chronic health problems.

The recruitment and four follow-up questionnaires (Appendix A) were developed in consultation with Survey Research Laboratory (SRL), University of Illinois, Chicago Circle Campus. The United States Office Management and Budget (OMB) approved the use of these questionnaires.

Interviewers

At each beach was a team of two interviewers trained by SRL in interviewer behavior and technique. A pretest was conducted on June 18, 1977, where each interviewer was to recruit five families and contact them for three weeks as described above. After the pretest, problems with the sampling scheme, recruitment process, and follow-up were to be resolved before the pilot study in July, 1977. Each interviewer was given a University of Illinois identification card and a letter from the Cleveland Department of Health authorizing the study. In addition, publicity was obtained through newspaper articles and poster signs at the two beaches. All interviewers were observed by directors of the study, and 10 percent of the participants in the study were called on the telephone to verify collected questionnaire information.

ANALYTICAL PROCEDURES

Design for Collection of Water Samples

Since an overall objective of this study was to develop the methodology to determine if there is a relationship between physical, chemical and/or biological components of water and the health of people bathing in those waters, a water sampling design was developed to test these water parameters at the two beaches. The sampling design for the collection of water samples was as follows: five samples were collected at each beach at 0900, 1200, and

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1500 hours on both Saturday and Sunday for three consecutive weekends starting July 16, 1977. All samples were collected 10 centimeters below the water surface. One sample was taken in knee depth water off of the center lifeguard stand; three samples were taken horizontally across the bathing area at chest depth (one off of the center lifeguard stand, and one each in the easterly-most and westerly-most direction that swimming was allowed; and one sample was taken at the furtherest point out that swimming was allowed off of the center lifeguard stand. In addition, one sample was taken at chest depth off the center lifeguard stand at 1200 hours each day from July 18-22 and July 25-29, 1977. Three samples were taken from point sources of pollution close to Edgewater Beach (one at the effluent from the Westerly Wastewater Treatment Plant and one sample each from two storm sewer overflows. All samples were collected, stored, and analyzed within time constraints as defined in Standard Methods (55). Ten percent of the collected water samples were split into two identical samples and analyzed by separate laboratories for quality control.

Analysis of Water Samples

All microbiological, chemical, and physical analyses of the collected water samples from the two beaches were performed by the City of Cleveland, Ohio, Division of Water, Water Quality Control Laboratory. Each of the 203 collected water samples were analyzed for total coliform, fecal coliform, *Escherichia coli*, fecal streptococcus, *Pseudomonas aeruginosa*, total staphylococcus, pH, chloride, BOD$_5$, turbidity, specific conductivity, suspended solids, total solids, and temperature.

The analysis of total coliform was done in accordance with *Standard Methods* 14th edition (55). The samples were filtered through 0.45 μm Gelman Filters and incubated in a Thelco Model 6M incubator for 18 hours at 35°C on M-Endo Broth. The colonies exhibiting a metallic green sheen were counted for the total coliforms number.

Fecal coliform and *Escherichia coli* analyses were done using a technique developed by the U.S. EPA (56). In general, samples filtered through 0.45 μm Gelman Filters were incubated in a Thelco Model 6M incubator for two hours at 35°C on mTEC Media. After two hours, the plates were transferred to a Blue M Magni-Whirl Water Bath and incubated for 20 hours at 44.5°C. After incubation, all yellow colonies were counted as fecal coliforms. After counting the fecal coliforms, the membranes were transferred to a sterile pad saturated with urea substrate for 15 minutes, and then these yellow colonies were counted as thermotolerant *Escherichia coli*.

For the determination of fecal streptococcus, E and EIA media were used (57). The filtered samples on the 0.45 μm Gelman Filters were first placed on E media and incubated in a Blue M Magni-Whirl Water Bath at 41.5°C for 48 hours. After the incubation period, the membranes were transferred to EIA media and incubated for 20 minutes at 41.5°C. The colonies showing a black precipitation on EIA media were counted as fecal streptococci.

The analysis of *Pseudomonas aeruginosa* was done in accordance with *Standard Methods* 14th edition (55) supplemented by an article by Levin and

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Cabelli, 1972 (58). The filtered samples on the 0.45 µM Gelman Filters were placed on mPA Agar and incubated in a Blue M Magni-Whirl Water Bath at 41.5°C for 48 hours. Colonies which were brownish to metallic black were counted as Pseudomonas aeruginosa.

Total staphylococcus was enumerated on the 0.45 µm Gelman Filters using Champmone Stone Agar as a medium (55). The prepared plates were incubated in a Thelmo Model GM Incubator for 48 hours at 35°C. All colonies except those which were mucoid or rough were counted as total staphylococci.

All of the above microbiological data were reported as number of colonies per 100 ml of sample. Three people counted the colonies from all of the samples. Internal controls were incorporated to check on the accuracy of counting.

All of the remaining variables were tested according to the 14th edition of Standard Methods (55) using the following instrumentation and technique:

a. The pH of the water samples was tested with a Fisher Acumet Model 420 Digital pH meter.

b. Chloride determination (mg/l) of collected water samples was made using a Mercuric Nitrate Titration.

c. Water samples for BOD$_5$ determination (mg/l) were incubated in a Freas Model 815 Low Temperature Incubator at 20°C. Dissolved oxygen for the BOD$_5$ analyses was tested with a Yellow Springs Instrument (YSI) Model 57 oxygen meter.

d. Turbidity was tested using an HF Turbidimeter, Fisher Model DRT 100. Turbidity was recorded in Formazin Turbidity units (FTU).

e. Specific conductivity (micromhos/centimeter) was tested using a YSI Model 31 Conductivity Bridge with Model 3401 Conductivity Cell.

f. Samples for suspended and total solids (mg/l) were dried in a Thelco Model 18 Forced Draft Drying Oven.

g. Water temperature in °C was made with a mercury-filled celsius thermometer.

h. Wave height (in meters) was estimated by eye sight.

Meteorological Information

The following meteorological data was obtained from the Lake Erie Regional Transportation Authority (LERTA) reported by Station XDI (Cleveland Crib #3) using a DARDC system (device for automatic remote data collection) from July 16, 1977 through July 31, 1977:

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a. **Wind direction**

b. **Wind speed (knots)**

c. **Precipitation (centimeters)**

d. **Air temperature (°C)**

e. **Time of collection**

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SECTION 6

RESULTS AND DISCUSSION

CHARACTERISTICS OF EDGEWATER AND HEADLANDS BEACH POPULATIONS

The study of measurements of health in people, after primary contact with recreational water, presents an unusual set of problems. First, it is most difficult to design a study which can relate infectious disease with bathing in recreational waters when there are so many factors that can contribute to infectious disease contagion. Second, there are many tactical problems in performing a study of this kind that need to be investigated. Since the few beach studies in the literature are not conclusive on specific guidelines to follow for conducting this type of study, it was necessary to conduct a pilot study to determine the availability and attrition of a study population, and to assess other factors that may influence the relationship between the acquisition of an infectious disease and recreational water quality. In this pretest, a total of 177 families, consisting of 634 persons, were contacted at both beaches during the three weekend recruitment.

The following results and discussions primarily will refer separately to the sample at each beach, although comparisons of the two samples will be addressed at times. The intent of this section is to identify those factors that may be important in designing and implementing future studies.

Family Attrition

Table 1 shows the number of families recruited at Edgewater and Headlands beaches and the family attrition rates at various time points during the study. There was an 18.0% attrition of the 83 families recruited at Edgewater Beach within 24 hours, with an additional 10.8% attrition by the end of the first week (Table 1). There was no further attrition of families after the first week. The attrition rate of families at Headlands Beach was 2.3 times lower than that at Edgewater Beach (Table 1). There was only 5.3% attrition of the 94 families recruited at Headlands Beach within 24 hours, with an additional 7.5% attrition over the final three-week follow-up period. The survey workers commented that some of the dropout at both beaches was associated with the fact that many families did not have home telephones and gave a neighbor or work telephone number which made follow-up contact more difficult. For future beach studies, it is recommended that home visits be made to families with no home telephones.

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TABLE 1. ATTRITION OF FAMILIES DURING STUDY PERIOD

	Beach			
	Edgewater Families		Headlands Families	
Time of Contact	No.	Attrition Rate (%)	No.	Attrition Rate (%)
Recruitment	83	--	94	--
24-hr. Post-Recruitment	68	18.1	89	5.3
1st Week	59	10.8	86	3.2
2nd Week	59	0.0	83	3.2
3rd Week	59	0.0	82	1.1
Total	--	28.9	--	12.8

In addition to determining attrition of families during the study period, data was gathered to see if attrition was related to family size (Table 2). It is noted in Table 2 that the proportion of attrition at Edgewater Beach increases directly with family size, while at Headlands Beach almost all of the attrition was in families with three or four members. No explanation can be given for the differences in attrition by family size and beach.

Although attrition of families was low at both beaches, it was unknown prior to this pilot study what the attrition rate would be. To encourage family participation after initial recruitment a promotional letter was distributed by the survey worker to every other family. The purpose was to determine whether the promotional letter had any impact on attrition. In general, letters of explanation are expected to help discourage excessive attrition (59). It can be seen in Table 3 that 40 families at Edgewater Beach were given the letter, 28 were not given the letter, and for 15 families it was not recorded whether or not they were given the letter. The overall attrition rate was twice as great for the families receiving the letter in comparison to those not given the letter. However, since there are 15 unknowns at this beach, the impact of the letter on attrition cannot be accurately interpreted. In fact, it would not be illogical to assume that the 15 unknowns were not given the letter because the survey workers were instructed to give the letter to every other family. If the 15 unknowns were added to the 28 families not given the letter, then there would be an equal distribution of those families given the letter and those not given the letter. When the unknowns are added to those families not given the letter, the total attrition rate is 23.3%. The difference between the total attrition rates between those given the letter (35.0%) and those not given the letter (23.3%) is due to sampling variation because those attrition rates are not significantly different ($P > 0.05$).

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TABLE 2. ATTRITION BY FAMILY SIZE

	Beach					
	Edgewater			Headlands		
Family Size	No. Families In Study	No. Families Dropped Out	Prop. of Attrition (%)	No. Families In Study	No. Families Dropped Out	Prop. of Attrition (%)
2	18	4	22.2	15	0	0.0
3	34	9	26.5	27	7	25.9
4	20	6	30.0	31	4	13.3
> 5	11	5	45.5	21	1	4.8
Total	83	24		94	12	

A better comparison of the impact of the promotional letter can be made at Headlands Beach because there were no "unknowns" (Table 3). It can be seen in Table 3 that the total attrition rates for those families given the letter and those families not given the letter are almost identical.

In this study, it is concluded that the promotional letter had no impact on attrition at either beach. Therefore, it is recommended for future studies of this nature that promotional letters not be used.

Age Characteristics of Individuals at Edgewater and Headlands Beaches

Of the 280 individuals recruited at Edgewater Beach, Table 4 shows that the majority was less than 15 years of age. Of these 280 recruited individuals, approximately 80% or 225 individuals were members of families who were able to be contacted by telephone and agreed to participate within 24 hours after recruitment. Such individuals are called participants. As may be seen from Table 4, the participants differed from the nonparticipants primarily in the 0-4 and 5-14 age groups.

Of the 354 individuals recruited at Headlands Beach, Table 4 shows that the majority was less than 15 years of age. Of these 354 recruited individuals, approximately 97% or 338 individuals were members of families who were able to be contacted by telephone and agreed to participate within 24 hours after recruitment. The participants differed from the nonparticipants primarily in the 0-4 age group.

Sex Distribution of Individuals at Edgewater and Headlands Beaches

The sex distribution of recruited, nonparticipating, and participating individuals at both beaches was approximately 42% males and 56% females (Table 5). As a consequence, the proportion of male and female participants was the same when compared to the nonparticipants.

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TABLE 3. EFFECT OF PROMOTIONAL LETTER ON FAMILY ATTRITION

Edgewater Beach Families

Time of Contact	No.	Given Letter Attrition Rate (%)	No.	Not Given Letter Attrition Rate (%)	No.	Unknown Attrition Rate (%)
Recruitment	40	--	28	--	15	-
Post-Recruited:						
24-hours	31	22.5	25	10.7	12	20.0
1st Week	26	12.5	23	7.1	10	13.3
2nd Week	26	0.0	23	0.0	10	0.0
3rd Week	26	0.0	23	0.0	10	0
Total	--	35.0	--	17.8	--	33.3

Headlands Beach Families

Time of Contact	No.	Given Letter Attrition Rate (%)	No.	Not Given Letter Attrition Rate (%)	No.	Unknown Attrition Rate (%)
Recruitment	40	--	54	--	0	0.0
Post-Recruited:						
24-hours	38	5.0	51	5.6	0	0.0
1st Week	36	10.0	50	1.8	0	0.0
2nd Week	35	12.5	48	3.7	0	0.0
3rd Week	35	0.0	47	1.8	0	0.0
Total	--	12.5	--	13.0	--	0.0

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TABLE 4. AGE DISTRIBUTION OF RECRUITED, NONPARTICIPATING, AND PARTICIPATING INDIVIDUALS AT EDGEWATER AND HEADLANDS BEACHES

Edgewater Beach

Age Group (yrs)	Recruited No.	Recruited %	Non-Participants No.	Non-Participants %	Participants No.	Participants %
0-4	54	19.3	15	27.3	39	17.3
5-14	96	34.3	13	23.6	83	36.9
15-18	10	3.6	3	5.5	7	3.1
19-59	115	41.1	20	36.4	95	42.2
≥ 60	0	0.0	0	0.0	0	0.0
Unknown	5	1.7	4	7.2	1	0.5
Total (percent)	280 (100.0)	100.0	55 (19.6)	100.0	225 (80.4)	100.0

Headlands Beach

Age Group (yrs)	Recruited No.	Recruited %	Non-Participants No.	Non-Participants %	Participants No.	Participants %
0-4	61	17.2	11	68.8	50	14.8
5-14	121	34.2	2	12.5	119	35.2
15-18	14	4.0	0	0.0	14	4.1
19-59	149	42.1	2	12.5	147	43.5
≥ 60	2	0.6	0	0.0	2	0.6
Unknown	7	1.9	1	6.2	6	1.8
Total (percent)	354 (100.0)	100.0	16 (4.5)	100.0	338 (96.5)	100.0

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TABLE 5. SEX DISTRIBUTION OF RECRUITED, NONPARTICIPATING, AND PARTICIPATING INDIVIDUALS AT EDGEWATER AND HEADLANDS BEACHES

Edgewater Beach

Sex	Recruited No.	Recruited %	Non-Participants No.	Non-Participants %	Participants No.	Participants %
Male	118	42.1	22	40.0	96	42.7
Female	157	56.1	33	60.0	124	55.1
Unknown	5	1.8	0	0.0	5	2.2
Total (percent)	280 (100.0)	100.0	55 (19.6)	100.0	225 (80.4)	100.0

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Headlands Beach

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Sex	Recruited No.	Recruited %	Non-Participants No.	Non-Participants %	Participants No.	Participants %
Male	152	42.9	7	43.8	145	42.9
Female	199	56.2	8	50.0	191	56.5
Unknown	3	1.9	1	6.2	2	0.6
Total (percent)	354 (100.0)	100.0	16 (4.5)	100.0	338 (96.5)	100.0

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Racial Characteristics of Individuals at Edgewater and Headlands Beaches

At Edgewater Beach, approximately 75% of the population was white, 13% was black, and 8% was other races (Table 6). Approximately one-half of the 55 nonparticipants were white, and over 36% and 12% were black and other races, respectively.

At Headlands Beach, the racial distribution of the recruited population was similar to that observed at Edgewater Beach (Table 6). Approximately one-half of the 16 nonparticipants were either white or black.

The greater proportion of participants at both beaches were white compared to the nonparticipating group.

Distribution of Participants by Age, Sex, and Beach

The first six Tables dealt with general characteristics of the recruitment, nonparticipant, and participant populations. The remaining Tables will deal only with the participants in much greater detail.

Table 7 presents the percent distribution of participants by age, sex, and beach. Distribution by age and sex were similar at each beach. At Edgewater Beach there were almost three times as many 0-4 year-age males as females, while Headlands Beach had almost twice as many males in this age group.

Distribution of Participants by Age, Race, and Beach

The distribution of participants by age, race, and beach is shown in Table 8. In this Table it can be seen that the age distributions for the respective ethnic groups were similar for both beaches.

Educational Attainment of the Health of Household

Level of education by the head of household was used as an index of socioeconomic status (SES) because of the sensitivity of asking a question about income directly. It is important to have some characterization of SES because this influences the age-duration of susceptibility and, consequently, the severity of illness for many infectious diseases (60).

As shown in Table 9, a higher percentage of the families at Headlands Beach had college or professional school education than the families at Edgewater Beach. However, it must be noted that 13.2% and 7.9% of the families at Edgewater and Headlands Beach, respectively, did not respond to this question.

Occupation of the Head of Household

All heads of household reported occupations that could be classified in one of seven categories as listed in Table 10. The four most frequently reported occupations of the Edgewater group, in order of magnitude, were craftsmen, managers, servicemen, and clerical workers, while at Headlands

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TABLE 6. DISTRIBUTION OF RACE OF RECRUITED, NONPARTICIPATING AND PARTICIPATING INDIVIDUALS AT EDGEWATER AND HEADLANDS BEACHES

Edgewater Beach

Race	Recruited		Non-Participants		Participants	
	No.	%	No.	%	No.	%
White	208	74.3	28	50.9	180	80.0
Black	40	14.3	20	36.4	20	8.9
Other	21	7.5	7	12.7	14	6.2
Unknown	11	3.9	0	0.0	11	4.9
Total	280	100.0	55	100.0	225	100.0

Headlands Beach

Race	Recruited		Non-Participants		Participants	
	No.	%	No.	%	No.	%
White	252	71.2	7	43.7	245	72.5
Black	64	18.1	8	50.0	56	16.6
Other	31	8.8	0	0.0	31	9.2
Unknown	7	1.9	1	6.3	6	1.7
Total	354	100.0	16	100.0	338	100.0

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Beach, the four most frequently reported occupations, in order of magnitude, were draftsmen, managers, professionals, and laborers.

TABLE 7. PERCENT DISTRIBUTION OF PARTICIPANTS BY AGE, SEX AND BEACH

Age Group (yrs)	Edgewater Beach Male	Edgewater Beach Female	Edgewater Beach Total	Headlands Beach Male	Headlands Beach Female	Headlands Beach Total
0-4	27.1	9.7	17.3	19.7	11.5	14.8
5-14	35.4	38.7	36.9	33.8	36.1	35.2
15-18	2.1	4.0	3.1	1.4	6.3	4.1
19-59	35.4	46.8	42.2	43.0	45.0	43.5
≥ 60	0.0	0.0	0.0	1.4	0.0	0.6
Unknown	0.0	0.8	0.5	0.7	1.1	1.8
Total %	100.0	100.0	100.0	100.0	100.0	100.0
Total No.*	96	124	225	142	191	338

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* The total number of Males and Females at each beach are not equal to the total number of participants at that beach because a few individuals did not have their sex recorded on the questionnaire.

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Summary of Characteristics of Edgewater and Headlands Beach Populations

The attrition of families at both beaches during the study period was low. Over 70% of the families from Edgewater Beach remained for the entire study period, while over 85% of the families from Headlands Beach remained till the study was completed. Attrition was directly proportional to family size at Edgewater Beach, while at Headlands Beach it was not related directly to family size. The promotional letter had no positive effect on reducing the attrition of families from either beach. The age characteristics of individuals at Edgewater and Headlands Beaches were similar in that the majority of the individuals recruited were less than 15 years of age. Also, the participants differed from the nonparticipants in the 0-4 age groups at both beaches. The sex distribution of male and female participants at both beaches was the same when compared to the nonparticipants. A greater proportion of the participants at both beaches were white compared to the nonparticipating group. A higher percentage of the families at Headlands Beach had college or professional school education than the families at Edgewater Beach.

CHARACTERISTICS OF BATHERS AND NONBATHERS AT EDGEWATER AND HEADLANDS BEACHES

Bathing Experience of Participants at Edgewater and Headlands Beaches

For this study, a bather is defined as someone who has primary contact with the recreational water at the beach. Bathers were subdivided into amount of body immersion to determine if more illness occurred in those individuals having total body immersion. A nonbather is someone who is at

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the beach, but has no primary contact with the water. Of the 563 participants in this study, 434 persons or 77%, reported they had primary contact with the water on recruitment day. At Edgewater Beach, 60% of the participants were bathers, while at Headlands Beach 88% of the participants were bathers (Table 11). Since Edgewater Beach was posted for no swimming and was aesthetically unappealing, it was not unexpected that there would be a smaller percentage of bathers at Edgewater Beach than at Headlands Beach.

Since there is variability in the amount of body immersion in the water for the bathing population, information was obtained indicating portions of body contact with the water (Table 12). Approximately 60% of the bathers at Edgewater Beach had total body immersion in the water, while approximately 80% at Headlands had total body immersion in the water.

TABLE 8. PERCENT DISTRIBUTION OF PARTICIPANTS BY AGE, RACE, AND BEACH

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Age Group (yrs)	Edgewater Beach White	Edgewater Beach Black	Edgewater Beach Other	Headlands Beach White	Headlands Beach Black	Headlands Beach Other
0-4	16.1	20.0	35.7	16.7	10.7	9.7
5-14	37.2	30.0	28.6	33.1	37.5	48.4
15-18	2.8	10.0	0.0	4.1	5.4	3.2
19-59	43.3	40.0	35.2	44.1	41.1	39.7
≥ 60	0.0	0.0	0.0	0.4	1.8	0.0
Unknown	0.6	0.0	0.0	1.6	3.5	0.0
Total %	100.0	100.0	100.0	100.0	100.0	100.0
Total No. *	180	20	14	245	56	31

* The total number of individuals in the ethnic groups at each beach are not equal to the total number of participants at that beach because a few individuals did not have their race recorded on the questionnaire.

Although information was obtained on the duration of water contact and number of hours in the beach area, this information was too unreliable to include in this report because, in many cases, participants reported the duration of water contact and number of hours in the beach area as one in the same. From personal observation of bathers at these beaches, many were observed to come out of the water and reenter at a later time. Furthermore, the participants were asked these questions via telephone follow-up as long as 24 hours after their bathing experience. It is unrealistic to think a parent will recall how long their children were in the water and how long their children actually had their faces in the water. Also, it was determined from this study that a low percentage of respondents confer with family members to obtain information about their bathing experience. Approximately seven percent of the respondents from Edgewater Beach and two percent

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TABLE 9. EDUCATION ATTAINED BY HEAD OF HOUSEHOLD OF PARTICIPATING FAMILIES AT EDGEWATER AND HEADLANDS BEACHES

Education Level Attained	Edgewater Beach		Headlands Beach	
	No.	%	No.	%
Professional	3	4.4	10	11.2
College	19	27.9	33	37.1
High School	37	54.5	37	41.6
Elementary	0	0.0	1	1.1
Non Formal	0	0.0	1	1.1
Unknown	9	13.2	7	7.9
Total	68	100.0	89	100.0

TABLE 10. OCCUPATION OF HEAD OF HOUSEHOLDS FOR PARTICIPATING FAMILIES AT EDGEWATER AND HEADLANDS BEACHES

Occupation	Edgewater Beach		Headlands Beach	
	No.	%	No.	%
Clerical	7	10.3	4	4.5
Craftsman	14	20.6	20	22.5
Laborer	6	8.8	14	15.7
Manager	8	11.8	17	19.1
Professional	6	8.8	15	16.9
Sales	2	2.9	6	6.7
Service	8	11.8	2	2.2
Unknown	17	25.0	11	12.4
Total	68	100.0	89	100.0

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TABLE 11. BATHING EXPERIENCE OF PARTICIPANTS AT EDGEWATER AND HEADLANDS BEACHES

Bathing Experience on Recruitment Day	Edgewater Beach		Headlands Beach	
	No.	%	No.	%
Bathers	136	60.4	298	88.2
Nonbathers	86	38.2	38	11.2
Unknown	3	1.4	2	0.6
Total	225	100.0	338	100.0

TABLE 12. AMOUNT OF BODY IMMERSION BY BATHERS AT EDGEWATER AND HEADLANDS BEACHES ON DAY OF RECRUITMENT

	Edgewater Beach		Headlands Beach	
	No.	%	No.	%
Total Body	80	58.8	237	79.5
Shoulders	11	8.1	15	5.0
Waist	19	14.0	28	9.4
Knees	12	8.8	15	5.0
Unknown	14	10.3	3	1.0
Total	136	100.0	298	100.0

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from Headlands Beach were found to confer with family members. The question of duration of water contact is an important one for a beach study, but is also most difficult to obtain with any reliability. Furthermore, it would be too unrealistic and expensive to hire enough survey workers to personally observe every bather in the study. It is recommended for future beach studies that the answer to the question of duration of water contact be obtained somewhat differently than was done in this study. Perhaps rephrasing the question about duration of water, and/or obtaining this information at the beach would be helpful.

Information was also gathered about the number of days the participants bathed throughout the three-week period (Table 13). It can be seen in this table that the majority of the participants at each beach did not bathe at other times during the study period. For persons who bathed other days, the highest percent bathed less than four days. More importantly, fewer people bathed at other times as the study progressed. It appears that the telephone health-interviewing process itself might have been a factor in affecting their attitudes toward subsequent bathing. This finding of less bathing as the study progressed was actually a beneficial one because many people had only one bathing experience from which they could have contacted a water-related illness.

Since 37% of the total study population bathed at times other than on recruitment day, it was of interest to determine where these swimming experiences occurred. As can be seen in Table 14, the same beach and public pools were named most often by both beach populations. There were only three persons (one family) that went to the other study beach.

Age Distribution of Bathers and Nonbathers at Edgewater and Headlands Beaches

In general, the percentage of bathers and nonbathers for each age group was similar at both beaches (Table 15). It can be seen that the highest percentage of bathers at both beaches is in the 5-14-year age group, while the highest percentage of nonbathers was in the 19-59-year age group.

Sex Distribution of Bathers and Nonbathers at Edgewater and Headlands Beaches

The sex distribution of bathers and nonbathers by beach is presented in Table 16. It can be seen that the distribution of bathers and nonbathers by sex is similar for each separate beach.

Race Distribution of Bathers and Nonbathers at Edgewater and Headlands Beaches

The race distribtuion of bathers and nonbathers by beach is presented in Table 17. This table shows that the distribution of bathers and nonbathers by race is similar for each separate beach.

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TABLE 13. NUMBER OF DAYS PARTICIPANTS BATHED DURING THE THREE WEEK INTERVAL

Edgewater Beach

No. Days Bathed Per Week	Percent Persons Bathing Each Week			
	Pre-Recruitment Week	Week Post Recruitment		
		1st	2nd	3rd
0	57.8	64.8	78.9	90.5
1-3	31.1	26.1	19.6	5.0
4-7	11.1	9.1	1.5	4.5
Total	100.0	100.0	100.0	100.0

6-1/2"

Headlands Beach

No. Days Bathed Per Week	Percent Persons Bathing Each Week			
	Pre-Recruitment Week	Week Post Recruitment		
		1st	2nd	3rd
0	66.0	57.1	72.6	80.6
1-3	24.5	35.5	26.1	15.6
4-7	9.5	7.4	1.3	3.8
Total	100.0	100.0	100.0	100.0

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TABLE 14. OTHER BATHING EXPERIENCES OF PARTICIPANTS FROM EDGEWATER AND HEADLANDS BEACHES

Location of Other Bathing Experience	Edgewater Beach Persons Reporting Other Bathing Before Recruit 1 Week	After Recruitment 1st Week	 2nd Week	 3rd Week
Edgewater	28	23	15	3
Headlands	3	0	2	0
Other Lake Beach	20	11	7	4
Public Pool	25	16	10	8
Other	19	20	8	4
Total No.	95	70	42	19
(Percent)	(42.2)	(35.2)	(21.1)	(9.5)
No other Bathing reported	135	129	157	180
(Percent)	(57.8)	(64.8)	(78.9)	(90.5)
Total No.	225	199	199	199
(Total Overall Percent)	(100.0)	(100.0)	(100.0)	(100.0)

Location of Other Bathing Experience	Headlands Beach Persons Reporting Other Bathing Before Recruit 1 Week	After Recruitment 1st Week	 2nd Week	 3rd Week
Headlands	42	55	51	19
Edgewater	0	7	0	0
Other Lake Beach	18	24	10	15
Public Pool	44	47	15	20
Other	11	12	3	7
Total No.	115	145	87	61
(Percent)	(34.0)	(42.9)	(27.4)	(19.4)
No other Bathing reported	223	182	231	253
(Percent)	(66.0)	(57.1)	(72.6)	(80.6)
Total No.	338	327	318	314
(Total Overall Percent)	(100.0)	(100.0)	(100.0)	(100.0)

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TABLE 15. AGE DISTRIBUTION OF BATHERS AND NONBATHERS AT EDGEWATER AND HEADLANDS BEACH ON RECRUITMENT DAY

	Bathing Experience					
	Edgewater Beach			Headlands Beach		
Age Group (yrs)	Bathers	Nonbathers	Unk	Bathers	Nonbathers	Unk
0-4	25	15	0	45	9	2
5-14	62	18	3	117	2	0
15-18	5	2	0	14	0	0
19-59	44	51	0	120	27	0
≥ 60	0	0	0	2	0	0
Unknown	0	0	0	0	0	0
Total No.	136	86	3	298	38	2
% of Total	60.4	38.2	1.4	88.2	11.2	0.6

TABLE 16. SEX DISTRIBUTION OF BATHERS AND NONBATHERS AT EDGEWATER AND HEADLANDS BEACHES

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Edgewater Beach

	Sex							
	Male		Female		Unknown		Total	
Bathing Experience	No.	%	No.	%	No.	%	No.	%
Bather	57	59.4	76	61.3	3	60.0	136	60.4
Nonbather	37	38.5	47	37.9	2	40.0	86	38.2
Unknown	2	2.1	1	0.8	0	0	3	1.4
Total	96	100.0	124	100.0	5	100.0	225	100.0

Headlands Beach

	Sex							
	Male		Female		Unknown		Total	
Bathing Experience	No.	%	No.	%	No.	%	No.	%
Bather	132	91.0	164	85.9	2	100.0	298	88.2
Nonbather	11	7.6	27	14.1	0	0	38	11.2
Unknown	2	1.4	0	0	0	0	2	0.6
Total	145	100.0	191	100.0	2	100.0	338	100.0

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TABLE 17. PERCENT DISTRIBUTION OF BATHERS AND NONBATHERS BY RACE AND BEACH

Bathing Experience on Recruitment Day	Race		
	White	Black	Other
EDGEWATER			
Bather	56.5	45.2	100.0
Nonbather	41.4	54.8	0
Unknown	2.1	0	0
Total %	100.0	100.0	100.0
Total No.	180	20	14
HEADLANDS BEACH			
Bather	89.7	88.1	83.8
Nonbather	9.6	11.9	16.2
Unknown	0.7	0	0
Total %	100.0	100.0	100.0
Total No.	245	56	31

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Educational Status of Bathers and Nonbathers at Edgewater and Headlands Beaches

The educational status of bathers and nonbathers at Edgewater and Headlands Beaches is presented in Table 18. The distribution of bathers and nonbathers by education is similar for each separate beach.

Summary of Bather and Nonbather Characteristics at Edgewater and Headlands Beaches

In summary, a higher percentage of participants were bathers at both beaches. The percentage of nonbathers at Headlands Beach was so small (11%) that it would require a great effort to get enough nonbathers for a control population in a larger study. Although the nonbather population was larger at Edgewater Beach (40%), it also would be difficult to get an adequate sample size of bathers and nonbathers for a large study because so few people frequent this beach. Although it would require a great effort in a larger study to obtain an adequate sample size of nonbathers at Headlands Beach and both bathers and nonbathers at Edgewater Beach, it still might be possible with changes in the sampling design over a longer duration. Unexpectedly, 63% of the bathers did not report bathing at other times during the study period. Also, fewer people bathed at other times as the study progressed. Finally, there were no meaningful differences between bathers and nonbathers at either beach with regard to age, sex, race or educational characteristics.

TABLE 18. EDUCATIONAL STATUS OF BATHERS AND NONBATHERS AT EDGEWATER AND HEADLANDS BEACHES ACCORDING TO LEVEL ATTAINED BY HEAD OF HOUSEHOLD

Bathing Experience on Recruitment Day	Percent Population by Educational Level						
	Prof.	Coll.	HS.	Elem.	None	Unknown	Total
Edgewater Beach							
Bather	3.7	23.5	55.1	0.0	0.8	16.9	100.0
Nonbather	5.8	32.6	55.8	0.0	0.0	5.8	100.0
Headlands Beach							
Bather	9.4	35.9	44.2	0.7	0.7	9.1	100.0
Nonbather	13.2	31.6	36.8	0.0	2.6	15.8	100.0

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ANALYSIS OF HEALTH DATA

It must be emphasized that the health information presented in this section is not an analysis of the effects of water quality on health. Illness rates are only presented to demonstrate a method of analysis that would be used for a larger study. Conclusions about the health effects of bathing in water with respect to any physical, chemical and/or biological components of water cannot be drawn from this pilot study.

Infectious Illnesses of Bathers and Nonbathers

Since participation of the bathers and nonbathers varied as to the length of time they remained in the study, all health analyses are best considered on the total number of illnesses per number of person-days. In Table 19, data are presented for self-reported infectious illnesses of bathers and nonbathers: no conclusions can be drawn from this Table. It is presented only to show what method of analysis would be used for a larger study.

Confounding Factors In The Analysis of Infectious Illness For a Beach Study

In the analysis of infectious illness for a beach study, there are many confounding factors that can make it difficult to relate an illness to a bathing experience. For example, in Table 19, infectious illness rates were compared for bathers and nonbathers, and for those bathers who had either total body immersion or only partial immersion. It well may be that a substantial portion of those individuals who were either nonbathers or partially-immersed bathers on the recruitment day resulted from some existing infectious condition. In order to eliminate such individuals from any statistical analysis, the health status of all individuals on recruitment day must be obtained in any subsequent study. Although the health status of the nonbathers on the day of recruitment was not directly obtained in this pilot study, information as to why nonbathers were not in the water was collected. Of the 86 nonbathers at Edgewater beach, 30 responded that they normally do go into water to bathe. Fifty-five nonbathers responded that they normally do go into water to bathe, but did not go into the water at Edgewater Beach primarily because: (a) the water looks dirty or is polluted (21/55); (b) they do not have a swimsuit with them (8/55); (c) they did not feel like bathing today (5/55). Only one individual reported the reason for not bathing was due to illness. However, there was no information recorded as to why 17 of the nonbathers, who said they normally bathed, were not bathing on the day of recruitment. Finally, no information was recorded for one nonbather as to whether he normally enters beach water for bathing purposes. Similarly for Headlands Beach, 26 of the 38 nonbathers indicated that they ordinarily do not bathe at beaches. Eleven nonbathers responded that they normally do go into water to bathe, but did not go into the water at Headlands Beach primarily because: (a) they did not feel like bathing today (4/11); (b) the water looks dirty (2/11). No information was recorded as to why four of the nonbathers, who said they normally bathed, were not bathing on the day of recruitment. Finally, no information was recorded for one nonbather as to whether he normally enters beach water for bathing purposes.

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TABLE 19. SELF-REPORTED INFECTIOUS ILLNESSES OF BATHERS* AND NONBATHERS AT EDGEWATER AND HEADLANDS BEACHES

Bathing Status	Edgewater Beach	Headlands Beach	Total
All Bathers			
Total No. of Illnesses	52[†]	122	174
Total No. of Person-Days	2415	5908	8323
Rate per 1,000	21.5	20.6	20.9
Bathers (Total Body Wet)			
Total No. of Illnesses	26	97	123
Total No. of Person-Days	1428	4690	6118
Rate per 1,000	18.2	20.7	20.1
Bathers (Excluding Head Wet)			
Total No. of Illnesses	22	25	47
Total No. of Person-Days	777	1218	1995
Rate per 1,000	28.3	20.5	23.6
Nonbathers			
Total No. of Illnesses	70	10	80
Total No. of Person-Days	1701	742	2443
Rate per 1,000	41.2	13.5	32.7
Total Bathers and Nonbathers			
Total No. of Illnesses	122	132	254
Total No. of Person-Days	4116	6650	10766
Rate per 1,000	29.6	19.8	23.6

[*] A bather is defined as someone who has contact with the water on recruitment day.

[†] Four individuals did not recall whether they had total body immersion while bathing.

Another confounding factor of Table 19 is that it includes those individuals who had multiple bathing experiences. A subsequent study would include a table with those individuals who only had total body immersion on the day of recruitment. In this pilot study, there were only two illnesses (210 person-days) reported from Edgewater Beach and 19 (1,470 person-days) reported from Headlands Beach by individuals who only had total body immersion on the day of recruitment.

Since age, race, and socioeconomic status (SES) are important interrelated factors for many infectious diseases, it is imperative that the health data of beach populations be examined after adjusting for these variables. A subsequent study would be examined with adjustment for the above demographic characterisitcs.

Chronic Diseases of Bathers and Nonbathers

In Tables 20 and 21, data are presented for chronic conditions of bathers and nonbathers at Edgewater and Headlands Beaches. The "other disease" category includes such chronic diseases as anemia, arthritis, diabetes, hypertension, cardiovascular disease, rheumatic fever, stroke, cancer, and renal problems. Since chronic diseases may alter susceptibility to infections, it should be included in the analysis of health data from a beach study. Once again, no conclusions can be drawn from the data presented in Tables 20 and 21. A subsequent study would include a table with chronic diseases reported by bathers who had total body immersion only on the day of recruitment.

SAMPLE SIZE FOR A SUBSEQUENT STUDY

If an illness rate of 23.6 per 1,000 (Table 19) is considered, approximately 850 families for each bathing beach is needed to be able to have an 80 percent chance of detecting a difference of 10 per 1,000 between the two beaches' illness rates using a type I error of 0.05. This sample size of number of families per beach is based on an average family size of 3.5. It is recommended that a subsequent study requiring 850 families not be conducted at Edgewater Beach because fewer than 250 families use this beach during the summer swimming season.

LENGTH OF FOLLOW-UP FOR SUBSEQUENT STUDY

One major difference between this pilot study and others that were previously conducted (25,32), is the three week follow-up. This follow-up period was selected for this study to record infectious illnesses with long incubation periods, and to determine if the study population can be followed successfully via telephone follow-up for three weeks. Although this study indicated that families are willing to be contacted via telephone for this period of time (Table 1), and illnesses were reported during the third week, it is felt that the three week follow-up is too long for the following reasons: (1) By the third week many of the illnesses reported probably are not related to an individual's bathing experience. (2) Most of the bacterial and viral illnesses related to bathing at a beach have an incubation period of less than 14 days (62). Therefore, a two week follow-up is recommended as the most appropriate for any subsequent study.

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TABLE 20. CHRONIC DISEASES OF BATHERS* AND NONBATHERS AT EDGEWATER BEACH

Bathing Status	Skin	Respiratory	Gastro-Intestinal	Other	Total
		Disease			
All Bathers					
Total No. of Diseases	1	17	4	19	41
Total No. of Person-Days	2415	2415	2415	2415	2415
Rate per 10,000	4.1	70.4	16.6	78.7	169.8
Nonbathers					
Total No. of Diseases	2	14	6	4	26
Total No. of Person-Days	1701	1701	1701	1701	1701
Rate per 10,000	11.8	82.3	35.3	23.5	152.9
Total (Bathers and Nonbathers)					
Total No. of Diseases	3	31	10	23	67
Total No. of Person-Days	4116	4116	4116	4116	4116
Rate per 10,000	7.3	75.3	24.3	55.9	162.8

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* A bather is defined as someone who had contact with the water on recruitment day.

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TABLE 21. CHRONIC DISEASES OF BATHERS* AND NONBATHERS AT HEADLANDS BEACH

	Disease				
Bathing Status	Skin	Respiratory	Gastro-Intestinal	Other	Total
All Bathers					
Total No. of Diseases	17	28	3	24	72
Total No. of Person-Days	5852	5852	5852	5852	5852
Rate per 10,000	29.0	47.8	5.1	41.0	123.0
Nonbathers					
Total No. of Diseases	0	3	0	0	3
Total No. Person-Days	756	756	756	756	756
Rate per 10,000	--	39.7	--	--	39.7
Total (Bathers and Nonbathers)					
Total No. of Diseases	17	31	3	25	76
Total No. of Person-Days	6608	6608	6608	6608	6608
Rate per 10,000	25.7	46.9	4.5	37.8	115.0

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[*] A bather is defined as someone who had contact with the water on recruitment day.

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WATER SAMPLE ANALYSIS

Multiple water samples were collected at each beach to determine if there were differences in these components between the days the samples were collected, between the five collection locations at each beach, and between the three daily time periods of sample collection. The mean concentrations for total coliform, fecal coliform, *Escherichia coli*, fecal streptococcus, *Pseudomonas aeruginosa*, total staphylococcus, pH, chloride, BOD, turbidity, specific conductivity, suspended solids, and total solids by time of day, location, and day for Edgewater Beach are given in Tables 22-34.

All of the above variables were analyzed statistically using analysis of variance (ANOVA) to determine if day of collection, time of collection, and collection location significantly explain any of the variability in the data. The two-way and three-way interactions indicated that day of collection, time of collection, and collection location generally are operating independently of each other ($p>0.05$). A significant difference ($p<0.05$) was found for all the variables in Tables 22-34 with regard to day of collection (Saturday vs. Sunday) except for total coliform and chloride concentrations. In addition, time of collection had a significant effect ($p<0.05$) on fecal coliform, *Escherichia coli*, fecal streptococcus, pH, and BOD concentrations. The five collection locations had an insignificant effect ($p>0.05$) for all of the above variables at Edgewater Beach.

Since several of the water measurements indicated a significant time effect, the Scheffe' Multiple Comparison Test (61) was used to ascertain which time points were significantly different. At Edgewater Beach, significant differences ($p<0.05$) were found for fecal coliform at 0900 and 1200 hours; for *Escherichia coli* at 0900 and 1200 hours; for fecal streptococcus at 0900 and 1500 hours; for pH at 0900 and 1200, 0900 and 1500, and 1200 and 1500 hours; and for BOD at 0900 and 1500 hours.

At Headlands Beach, the statistical approach was identical to that used for Edgewater Beach. The mean concentrations for total coliform, fecal coliform, *Escherichia coli*, fecal streptococcus, *Pseudomonas aeruginosa*, total straphylococcus, pH, chloride, BOD, turbidity, specific conductivity, suspended solids, and total solids by time of day, location, and for Headlands Beach are given in Tables 35-47.

All of the variables in Tables 35-47 were analyzed statistically using ANOVA to determine if day of collection, time of collection, and collection location significantly explain any of the variability in the data. Once again the two-way and three-way interactions indicated that day of collection, time of collection, and collection location generally are operating independently of each other ($p>0.05$). A significant difference ($p<0.05$) was found for fecal streptococcus, pH, turbidity, specific conductivity, suspended solids and total solids concentrations with regard to day of collection (Saturday vs. Sunday). A significant time effect ($p<0.05$) was found for all the variables except fecal coliform, *Escherichia coli*, total staphylococcus, chloride, BOD, and total solids concentrations. In addition, a significant collection location effect ($p<0.05$) was found only for fecal streptococcus,

TABLE 22. MEAN TOTAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	17580 (3)	23306 (3)	7593 (3)	7600 (3)	19840 (3)	4407 (3)	13333 (3)	17490 (3)	10920 (3)	18050 (3)	5083 (3)	5053 (3)	10017 (3)	5916 (3)	4517 (3)	11380 (45)
Sun.	21120 (3)	9560 (3)	15078 (3)	10003 (3)	11477 (3)	7850 (3)	5459 (3)	11173 (3)	8917 (3)	6450 (3)	4390 (3)	4373 (3)	4300 (3)	3680 (3)	2873 (3)	8447 (45)
Overall Mean	14316 (30)					10405 (30)					5020 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 23. MEAN FECAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	2900 (3)	3102 (3)	1645 (3)	1200 (3)	3105 (3)	537 (3)	670 (3)	270 (3)	543 (3)	637 (3)	1190 (3)	1517 (3)	460 (3)	530 (3)	803 (3)	1274 (45)
Sun.	616 (3)	212 (3)	740 (3)	782 (3)	679 (3)	657 (3)	296 (3)	418 (3)	388 (3)	72 (3)	310 (3)	294 (3)	290 (3)	570 (3)	222 (3)	436 (45)
Overall Mean +	1498 (30)					449 (30)					619 (30)					

* C.K. (Center knee). W.C. (West chest). E.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean fecal coliform concentrations are significantly different ($p < 0.05$) between 0900 and 1200 hours as determined by the Scheffé multiple comparison test (61).

TABLE 24. MEAN ESCHERICHIA COLI CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	2807 (3)	2907 (3)	1341 (3)	1083 (3)	2836 (3)	460 (3)	650 (3)	250 (3)	503 (3)	603 (3)	1043 (3)	1370 (3)	407 (3)	510 (3)	353 (3)	1141 (45)
Sun.	442 (3)	159 (3)	539 (3)	579 (3)	512 (3)	573 (3)	276 (3)	383 (3)	320 (3)	58 (3)	252 (3)	254 (3)	247 (3)	493 (3)	198 (3)	348 (45)
Overall Mean+	1320 (30)					402 (30)					513 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean Escherichia coli concentrations are significantly different ($p<0.05$) between 0900 and 1200 hours as determined by the Scheffé multiple comparison test (61).

TABLE 25. MEAN FECAL STREPTOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	1328 (3)	956 (3)	608 (3)	492 (3)	952 (3)	173 (3)	300 (3)	157 (3)	183 (3)	283 (3)	227 (3)	303 (3)	257 (3)	60 (3)	50 (3)	439 (43)
Sun.	218 (3)	109 (3)	154 (3)	147 (3)	176 (3)	154 (3)	215 (3)	152 (3)	114 (3)	158 (3)	75 (3)	297 (3)	120 (3)	242 (3)	81 (3)	161 (45)
Overall Mean +	514 (30)					189 (30)					179 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean fecal streptococcus concentrations are significantly different ($p<0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple test (61).

TABLE 26. MEAN *PSEUDOMONAS AERUGINOSA* CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	72 (3)	242 (3)	87 (3)	113 (3)	179 (3)	42 (2)	145 (3)	68 (3)	157 (3)	57 (3)	131 (3)	75 (3)	94 (3)	56 (3)	61 (2)	108 (43)
Sun.	28 (3)	30 (3)	28 (3)	17 (3)	38 (3)	12 (3)	34 (3)	20 (3)	21 (3)	12 (3)	13 (3)	20 (3)	21 (3)	27 (3)	8 (3)	22 (45)
Overall Mean	83 (30)					57 (29)					50 (29)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 27. MEAN TOTAL STAPHYLOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	4110 (3)	3800 (3)	3427 (3)	3333 (3)	6533 (3)	5750 (3)	8393 (3)	3133 (3)	4933 (3)	7140 (3)	13943 (3)	6267 (3)	14300 (3)	18600 (3)	11666 (3)	7689 (45)
Sun.	1350 (2)	1200 (2)	1550 (2)	570 (2)	1125 (2)	1000 (2)	835 (2)	805 (2)	800 (2)	925 (2)	800 (2)	800 (2)	600 (2)	800 (2)	650 (2)	921 (30)
Overall Mean	3008 (25)					3871 (25)					8065 (25)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 28. MEAN pH CONCENTRATION BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	8.2 (3)	8.2 (3)	8.2 (3)	8.1 (3)	8.2 (3)	8.3 (3)	8.3 (3)	8.4 (3)	8.4 (3)	8.4 (3)	8.4 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.37 (45)
Sun.	8.7 (3)	8.4 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.6 (3)	8.6 (3)	8.7 (3)	8.6 (3)	8.9 (3)	8.8 (3)	8.7 (3)	8.7 (3)	8.7 (3)	8.63 (45)
Overall Mean+	8.34 (30)					8.47 (30)					8.61 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean pH concentrations are significantly different ($p < 0.05$) between 0900 and 1200, and 1500, and 1200 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 29. MEAN CHLORIDE CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	35.3 (3)	29.3 (3)	28.7 (3)	28.7 (3)	28.7 (3)	30.0 (3)	30.3 (3)	28.3 (3)	28.7 (3)	27.7 (3)	31.3 (3)	28.0 (3)	29.0 (3)	27.7 (3)	27.7 (3)	29.23 (45)
Sun.	25.3 (3)	25.7 (3)	25.3 (3)	25.7 (3)	25.3 (3)	26.3 (3)	26.0 (3)	22.7 (3)	26.0 (3)	26.7 (3)	24.7 (3)	25.0 (3)	24.7 (3)	25.0 (3)	25.0 (3)	25.30 (45)
Overall Mean	27.80 (30)					27.23 (30)					26.80 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 30. MEAN BOD_5 CONCENTRATION (mg/1) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	1.7 (3)	2.5 (3)	2.0 (3)	2.3 (3)	2.1 (3)	2.8 (3)	2.4 (3)	2.1 (3)	2.5 (3)	1.9 (3)	3.3 (3)	2.6 (3)	2.8 (3)	2.7 (3)	2.3 (3)	2.37 (45)
Sun.	2.4 (3)	2.4 (3)	3.1 (3)	4.3 (3)	2.5 (3)	3.0 (3)	3.4 (3)	2.8 (3)	3.3 (3)	3.2 (3)	4.1 (3)	3.9 (3)	4.4 (3)	3.3 (3)	3.4 (3)	3.30 (45)
Overall Mean +	2.54 (30)					2.72 (30)					3.29 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean BOD concentrations are significantly different ($p<0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 31. MEAN TURBIDITY CONCENTRATION (FORMAZIN TURBIDITY UNITS) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	3.4 (3)	9.7 (3)	3.7 (3)	3.9 (3)	3.6 (3)	8.9 (3)	8.9 (3)	9.7 (3)	3.1 (3)	10.8 (3)	17.3 (3)	9.1 (3)	8.6 (3)	6.1 (3)	7.5 (3)	7.63 (45)
Sun.	1.9 (3)	1.8 (3)	2.1 (3)	1.6 (3)	1.9 (3)	2.5 (3)	2.3 (3)	2.0 (3)	2.4 (3)	2.1 (3)	3.6 (3)	3.2 (3)	3.4 (3)	2.9 (3)	2.9 (3)	2.47 (45)
Overall Mean	3.37 (30)					5.26 (30)					6.46 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 32 .MEAN SPECIFIC CONDUCTIVITY CONCENTRATION (MICROMHOS/CENTIMETER) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	330.3 (3)	332.3 (3)	313.3 (3)	311.3 (3)	314.0 (3)	315.3 (3)	329.3 (3)	309.7 (3)	310.3 (3)	308.7 (3)	336.7 (3)	318.3 (3)	336.7 (3)	328.3 (3)	315.7 (3)	320.70 (45)
Sun.	293.0 (3)	291.3 (3)	294.3 (3)	293.0 (3)	289.0 (3)	307.0 (3)	305.7 (3)	301.7 (3)	311.3 (3)	295.3 (3)	316.0 (3)	298.3 (3)	317.0 (3)	303.7 (3)	298.0 (3)	300.97 (45)
Overall Mean	306.20 (30)					309.43 (30)					316.87 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 33. MEAN SUSPENDED SOLIDS CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	19.3 (3)	28.7 (3)	17.3 (3)	19.3 (3)	12.3 (3)	37.3 (3)	22.3 (3)	29.0 (3)	20.7 (3)	22.7 (3)	71.7 (3)	65 (3)	32.3 (3)	22.7 (3)	22.0 (3)	29.50 (45)
Sun.	16.7 (3)	10.7 (3)	15.3 (3)	13.3 (3)	7.7 (3)	15.3 (3)	14.7 (3)	10.0 (3)	8.7 (3)	6.7 (3)	23.7 (3)	19.0 (3)	11.0 (3)	15.3 (3)	12.3 (3)	13.37 (45)
Overall Mean	16.07 (30)					18.73 (30)					29.50 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 34. MEAN TOTAL SOLIDS CONCENTRATION (mg/1) BY TIME OF DAY, LOCATIONS, AND DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	253.0 (3)	229.0 (3)	221.7 (3)	229.0 (3)	213.0 (3)	241.7 (3)	219.3 (3)	231.3 (3)	208.3 (3)	227.0 (3)	260.7 (3)	254.3 (3)	212.7 (3)	216.0 (3)	210.3 (3)	228.47 (45)
Sun.	185.7 (3)	186.3 (3)	189.3 (3)	186.0 (3)	198.0 (3)	182.3 (3)	182.3 (3)	203.0 (3)	194.0 (3)	189.0 (3)	194.7 (3)	206.3 (3)	202.3 (3)	196.7 (3)	195.7 (3)	192.77 (45)
Overall Mean	209.10 (30)					207.83 (30)					214.97 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 35. MEAN TOTAL COLIFORM CONCENTRATION (NUMBER/ 100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	498 (3)	397 (3)	327 (3)	322 (3)	355 (3)	227 (3)	453 (3)	180 (3)	530 (3)	177 (3)	2127 (3)	1870 (3)	1270 (3)	533 (3)	1120 (3)	697 (45)
Sun.	1069 (3)	91 (3)	114 (3)	79 (3)	118 (3)	237 (3)	88 (3)	249 (3)	247 (3)	45 (3)	1460 (2)	196 (3)	540 (3)	670 (3)	169 (3)	337 (43)
Overall Mean +	344 (30)					243 (30)					1008 (28)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean total coliform concentrations are significantly different ($p < 0.05$) between 1200 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 36 . MEAN FECAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	56 (3)	36 (3)	41 (3)	91 (3)	31 (3)	41 (3)	20 (3)	27 (3)	43 (3)	15 (3)	53 (3)	46 (3)	34 (3)	37 (3)	28 (3)	340 (45)
Sun.	1029 (3)	9 (3)	31 (3)	9 (3)	18 (3)	93 (3)	14 (3)	62 (3)	51 (3)	13 (3)	183 (3)	47 (3)	262 (3)	143 (3)	86 (3)	137 (45)
Overall Mean	135 (30)					38 (30)					92 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 37. MEAN ESCHERICHIA COLI CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	48 (3)	33 (3)	37 (3)	82 (3)	28 (3)	35 (3)	17 (3)	22 (3)	38 (3)	14 (3)	49 (3)	43 (3)	32 (3)	37 (3)	26 (3)	36 (45)
Sun.	1002 (3)	9 (3)	18 (3)	7 (3)	12 (3)	83 (3)	12 (3)	60 (3)	42 (3)	11 (3)	122 (3)	37 (3)	208 (3)	143 (3)	56 (3)	122 (45)
Overall Mean	128 (30)					34 (30)					75 (30)					

* C.K. (Center knee). W.C. West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 38. MEAN FECAL STREPTOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	73 (3)	54 (3)	24 (3)	36 (3)	15 (3)	25 (3)	9 (3)	12 (3)	15 (3)	10 (3)	36 (3)	19 (3)	22 (3)	19 (3)	12 (3)	25 (45)
Sun.	38 (3)	15 (3)	12 (3)	5 (3)	2 (3)	102 (3)	11 (3)	44 (3)	41 (3)	18 (3)	267 (3)	86 (3)	147 (3)	143 (3)	62 (3)	66 (45)
Overall Mean +	27 (30)					29 (30)					81 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean fecal streptococcus concentrations are significantly different ($p < 0.05$) between 0900 and 1500 hours, and 1200 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 39. MEAN PSEUDOMONAS AERUGINOSA CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	10 (3)	2 (3)	1 (3)	2 (3)	1 (3)	5 (3)	8 (3)	3 (3)	4 (3)	4 (3)	26 (3)	7 (3)	14 (3)	91 (3)	16 (3)	13 (45)
Sun.	4 (3)	1 (3)	1 (3)	1 (3)	1 (3)	18 (3)	2 (3)	4 (3)	5 (3)	3 (3)	5 (3)	8 (3)	6 (3)	36 (3)	3 (3)	7 (45)
Overall Mean +	3 (30)					6 (30)					21 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall Pseudomonas aeruginosa concentrations are significantly different ($p < 0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 40. MEAN TOTAL STAPHYLOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	947 (3)	757 (3)	563 (3)	680 (3)	857 (3)	817 (3)	793 (3)	707 (3)	857 (3)	557 (3)	1140 (3)	607 (3)	2377 (3)	1057 (3)	627 (3)	893 (45)
Sun.	770 (2)	415 (2)	200 (2)	280 (2)	520 (2)	1540 (2)	410 (2)	520 (2)	2760 (2)	1200 (2)	1210 (2)	560 (2)	750 (2)	905 (2)	470 (2)	834 (30)
Overall Mean	631 (25)					962 (25)					1014 (25)					

* C.K. (Center knee). W.C. (West chest). E.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 41. MEAN pH CONCENTRATION BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	8.4 (3)	8.5 (3)	8.5 (3)	8.4 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.5 (3)	8.6 (3)	8.6 (3)	8.6 (3)	8.6 (3)	8.53 (45)
Sun.	8.6 (3)	8.6 (3)	8.6 (3)	8.6 (3)	8.6 (3)	8.6 (3)	8.7 (3)	8.6 (3)	8.6 (3)	8.7 (3)	8.7 (3)	8.7 (3)	8.7 (3)	8.7 (3)	8.8 (3)	8.63 (45)
Overall Mean +	8.53 (30)					8.58 (30)					8.64 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean pH concentrations are significantly different ($p < 0.05$) between 0900 and 1500, and 1200 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 42. MEAN CHLORIDE CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	34.7 (3)	30.0 (3)	30.0 (3)	29.3 (3)	29.0 (3)	31.0 (3)	31.0 (3)	30.7 (3)	30.7 (3)	31.0 (3)	30.3 (3)	30.3 (3)	30.0 (3)	29.3 (3)	28.7 (3)	30.37 (45)
Sun.	25.3 (3)	25.0 (3)	25.7 (3)	26.0 (3)	26.0 (3)	25.3 (3)	25.0 (3)	25.3 (3)	25.3 (3)	25.3 (3)	24.7 (3)	24.7 (3)	23.7 (3)	24.7 (3)	23.3 (3)	25.03 (45)
Overall Mean	28.07 (30)					28.07 (30)					26.93 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 43. MEAN BOD_5 CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	3.2 (3)	2.1 (3)	2.4 (3)	2.0 (3)	1.9 (3)	3.0 (3)	2.6 (3)	2.5 (3)	2.4 (3)	2.1 (3)	3.2 (3)	2.6 (3)	3.2 (3)	2.8 (3)	2.3 (3)	2.53 (45)
Sun.	2.3 (3)	1.8 (3)	1.7 (3)	1.9 (3)	1.8 (3)	3.0 (3)	2.4 (3)	2.7 (3)	3.0 (3)	2.4 (3)	3.0 (3)	2.2 (3)	2.6 (3)	3.2 (3)	2.2 (3)	2.40 (45)
Overall Mean	2.11 (30)					2.60 (30)					2.73 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

TABLE 44. MEAN TURBIDITY CONCENTRATION (FORMAZIN TURBIDITY UNITS) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	7.9 (3)	5.4 (3)	5.3 (3)	4.1 (3)	3.4 (3)	7.6 (3)	7.9 (3)	5.6 (3)	5.7 (3)	4.6 (3)	8.3 (3)	6.2 (3)	7.0 (3)	4.7 (3)	4.8 (3)	5.90 (45)
Sun.	3.5 (3)	2.3 (3)	2.1 (3)	1.9 (3)	1.8 (3)	5.7 (3)	3.7 (3)	4.4 (3)	3.9 (3)	2.8 (3)	8.6 (3)	6.7 (3)	7.0 (3)	6.7 (3)	4.0 (3)	4.33 (45)
Overall Mean +	3.76 (30)					5.19 (30)					6.40 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean turbidity concentrations are significantly different ($p < 0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 45 MEAN SPECIFIC CONDUCTIVITY CONCENTRATION (MICROMHOS/CENTIMETER) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	305.7 (3)	294.0 (3)	305.0 (3)	302.0 (3)	309.0 (3)	323.7 (3)	328.7 (3)	321.0 (3)	311.3 (3)	324.7 (3)	330.0 (3)	310.7 (3)	327.3 (3)	329.7 (3)	308.3 (3)	314.40 (45)
Sun.	292.3 (3)	288.0 (3)	286.0 (3)	295.0 (3)	293.0 (3)	302.7 (3)	299.0 (3)	297.0 (3)	296.7 (3)	297.3 (3)	299.7 (3)	304.3 (3)	307.7 (3)	308.7 (3)	302.7 (3)	298.00 (45)
Overall Mean +	297.00 (30)					310.20 (30)					312.90 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean specific conductivity concentrations are significantly different ($p< 0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 46·MEAN SUSPENDED SOLIDS CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	31.3 (3)	16.3 (3)	18.0 (3)	17.0 (3)	14.3 (3)	37.3 (3)	29.7 (3)	30.0 (3)	27.7 (3)	17.0 (3)	33.7 (3)	21.7 (3)	25.3 (3)	23.3 (3)	16.7 (3)	23.93 (45)
Sun.	11.0 (3)	6.0 (3)	10.3 (3)	5.0 (3)	6.7 (3)	22.0 (3)	15.0 (3)	17.7 (3)	17.0 (3)	11.7 (3)	41.7 (3)	25.7 (3)	38.0 (3)	24.0 (3)	12.0 (3)	17.60 (45)
Overall Mean +	13.60 (30)					22.50 (30)					26.20 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

+ The overall mean suspended solids concentrations are significantly different ($p < 0.05$) between 0900 and 1500 hours as determined by the Scheffé multiple comparison test (61).

TABLE 47. MEAN TOTAL SOLIDS CONCENTRATION (mg/l) BY TIME OF DAY, LOCATION, AND DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day															
	0900					1200					1500					
Location*	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	C.K.	W.C.	C.C.	E.C.	C.L.	Overall Mean
Sat.	213.7 (3)	205.7 (3)	218.7 (3)	223.0 (3)	215.7 (3)	227.7 (3)	211.7 (3)	220.0 (3)	225.3 (3)	206.0 (3)	244.7 (3)	232.7 (3)	229.7 (3)	221.0 (3)	200.0 (3)	219.67 (45)
Sun.	207.3 (3)	188.0 (3)	186.0 (3)	175.0 (3)	205.3 (3)	214.3 (3)	177.3 (3)	169.0 (3)	204.3 (3)	183.7 (3)	207.7 (3)	193.3 (3)	221.0 (3)	191.0 (3)	185.3 (3)	193.90 (45)
Overall Mean	203.83 (30)					203.93 (30)					212.63 (30)					

* C.K. (Center knee). W.C. (West chest). C.C. (Center chest). E.C. (East chest). C.L. (Center limit).

ph, turbidity, and suspended solids concentrations.

The Scheffe' Multiple Comparison Test (61) was again used to determine if time differences for concentrations of the above variables were at 0900 and 1200, 0900 and 1500, and/or 1200 and 1500 hours. At Headlands Beach, significant differences ($p<0.05$) were found for total coliform at 1200 and 1500 hours; for fecal streptococcus at 0900 and 1500, and 1200 and 1500 hours; for *Pseudomonas aeruginosa* at 0900 and 1500 hours; for pH at 0900 and 1500, and 1200 and 1500 hours; for turbidity at 0900 and 1500 hours; for specific conductivity at 0900 and 1500 hours; and for suspended solids at 0900 and 1500 hours (Tables 35-47).

The water data were first analyzed by considering only the three factors of day, time, and sample point with the omission of the weekend factor. Subsequent analyses considered all four factors in the analyses of variance (ANOVAS). Even so, there were only minor changes between the three-way and corresponding four-way ANOVAS.

In a similar manner to the first set of ANOVAS, when the weekend factor was considered in the subsequent set of four-factor ANOVAS, many of the two- and three-way interactions were found to be significant ($p<0.05$). Therefore, the water variables were compared for differential weekend effects by the Scheffe' Multiple Comparison Test (61) for different time-day combinations (Tables 48-73). Generally, the microbiological variables at Edgewater Beach had the greatest amount of significant differences on Saturday at 0900 between the weekends (Tables 48-53). The variability of the physical-chemical variables at Edgewater Beach by day and time of day between the weekends was not as clear-cut as it was for the microbiological variables (Tables 54-60). When the same comparisons were made at Headlands Beach, there was not much variability of the microbiological variables by day and time of day between the weekends (Tables 61-66). Also, the observed concentrations of the microbiological variables at Headlands Beach were generally much lower than the observed concentrations of the same variables at Edgewater Beach. Although the variation of the physical-chemical variables at Headlands Beach by day and time of day between weekends was not clear-cut, it was similar to that found at Edgewater Beach (Tables 67-73). Also, the observed concentrations of the physical-chemical variables at both beaches were similar. It is clear from these tables that in order to investigate health effects of recreational water as related to some water quality variable, one needs to know the specific time of day and day of weekend that an individual was exposed. However, as it may be seen in Tables 22-47, little is to be gained by taking water samples at various locations.

Water samples were also collected at both beaches on Monday through Friday, at one time (1200 hours), and one sample point (center chest depth). Mean concentrations of the microbiological, physical, and chemical variables for Edgewater and Headlands Beach are given in Tables 74 and 75, respectively. An ANOVA was used to test a day effect of the water samples collected on Monday through Friday. Significant differences ($p<0.05$) were found only for BOD_5 and suspended solids concentrations at Edgewater Beach, while the only difference found at Headlands Beach was for the fecal streptococcus concentration.

TABLE 48. MEAN TOTAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	14,740 ^{a,b} (5)	451 ^{b} (5)	15,084 ^{a} (5)	256 ^{b} (5)	6,820 (5)	1,016 (5)	6,394 (30)
2	612 ^{c} (5)	292 ^{c} (5)	316 ^{c} (5)	254 ^{c} (5)	52 (5)	674 (5)	367 (30)
3	30,200 (5)	39,600 (5)	23,120 (5)	23,400 (5)	11,480 (5)	10,080 (5)	22,980 (30)
Over-all Mean	15,184 (15)	13,448 (15)	12,840 (15)	7,970 (15)	6,117 (15)	3,923 (15)	9,914 (90)
	14,316 (30)		10,405 (30)		5,020 (30)		

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[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 49. MEAN TOTAL FECAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	2,250^{a,b} (5)	30^{b} (5)	936 (5)	114 (5)	566^{b} (5)	298 (5)	699 (30)
2	61^{c} (5)	39^{c} (5)	16 (5)	54 (5)	10^{c} (5)	58 (5)	40 (30)
3	4,860 (5)	1,748 (5)	642 (5)	930 (5)	2,124 (5)	656 (5)	1,827 (30)
Overall Mean	2,390 (15)	606 (15)	531 (15)	366 (15)	900 (15)	337 (15)	
	1,498 (30)		449 (30)		616 (30)		855 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 50. MEAN TOTAL ESCHERICHIA COLI CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

Weekend \ Day	Time of Day						Overall Mean
	0900		1200		1500		
	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	2,182 ^{a,b} (5)	26 ^{b} (5)	878 (5)	99 (5)	276 ^{b} (5)	268 (5)	621 (30)
2	39 ^{c} (5)	33 ^{c} (5)	12 (5)	53 (5)	10 ^{c} (5)	51 (5)	33 (30)
3	4,360 (5)	1,280 (5)	590 (5)	778 (5)	1,924 (5)	548 (5)	1,580 (30)
Over-all Mean	2,194 (15)	446 (15)	493 (15)	310 (15)	737 (15)	289 (15)	
	1,320 (30)		402 (30)		513 (30)		745 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 51. MEAN TOTAL FECAL STREPTOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	928[a,b] (5)	39 (5)	224 (5)	14 (5)	106 (5)	221 (5)	255 (30)
2	33[c] (5)	22 (5)	34 (5)	13 (5)	10[c] (5)	63 (5)	29 (30)
3	1,640 (5)	422 (5)	400 (5)	450 (5)	667 (3)	205 (5)	628 (28)
Over-all Mean	869 (15)	161 (15)	219 (15)	159 (15)	198 (13)	163 (15)	
	514 (30)		189 (30)		179 (28)		297 (88)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 52. MEAN TOTAL PSEUDOMONAS AERUGINOSA CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	194 [a] (5)	8 (5)	130 [a] (5)	3 (5)	93 [a,b] (5)	12 (5)	74 (30)
2	14 [c] (5)	4 (5)	5 [c] (5)	3 (5)	2 [c] (5)	4 (5)	5 (30)
3	208 (5)	73 (5)	173 (4)	54 (5)	178 (4)	37 (5)	116 (28)
Over-all Mean	139 (15)	28 (15)	98 (14)	20 (15)	85 (14)	18 (15)	
	83 (30)		57 (29)		50 (29)		64 (88)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 53. MEAN TOTAL STAPHYLOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	8,200 ^{a,b} (5)	--	14,280 ^{a,b} (5)	--	32,400 ^{a,b} (5)	--	18,293 (15)
2	1,042 ^{c} (5)	230 ^{c} (5)	390 ^{c} (5)	166 ^{c} (5)	586 ^{c} (5)	380 (5)	466 (30)
3	3,480 (5)	2,088 (5)	2,940 (5)	1,580 (5)	5,880 (5)	1,080 (5)	2,841 (30)
Overall Mean	4,241 (15)	1,159 (10)	5,870 (15)	873 (10)	12,955 (15)	730 (10)	
	3,008 (25)		3,871 (25)		8,065 (25)		4,981 (75)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 54. MEAN pH CONCENTRATION BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	8.5^{a,b} (5)	8.6^{b} (5)	8.6^{a,b} (5)	8.8^{b} (5)	8.6^{a,b} (5)	8.9^{b} (5)	8.66 (30)
2	7.9^{c} (5)	8.6^{c} (5)	8.2 (5)	8.7^{c} (5)	8.4 (5)	8.9^{c} (5)	8.43 (30)
3	8.2 (5)	8.4 (5)	8.3 (5)	8.3 (5)	8.4 (5)	8.6 (5)	8.33 (30)
Over-all Mean	8.18 (15)	8.50 (15)	8.36 (15)	8.58 (15)	8.47 (15)	8.76 (15)	
	8.34 (30)		8.47 (30)		8.61 (30)		8.48 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 55. MEAN CHLORIDE CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	21.6 [a,b] (5)	21.0 [a,b] (5)	22.0 [a,b] (5)	22.4 (5)	22.2 [a,b] (5)	20.2 [a,b] (5)	21.57 (30)
2	38.8 [c] (5)	27.8 (5)	34.6 [c] (5)	25.2 (5)	32.8 (5)	25.4 (5)	30.77 (30)
3	30.0 (5)	27.6 (5)	30.2 (5)	29.0 (5)	31.2 (5)	29.0 (5)	29.50 (30)
Overall Mean	30.13 (15)	25.47 (15)	28.93 (15)	25.53 (15)	28.73 (15)	24.87 (15)	
	27.80 (30)		27.23 (30)		26.80 (30)		27.28 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 56. MEAN BOD_5 CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	2.7 [b] (5)	2.5 (5)	2.9 [b] (5)	2.7 [a] (5)	3.1 [b] (5)	3.3 [a] (5)	2.88 (30)
2	2.3 (5)	3.2 (5)	2.9 [c] (5)	4.1 [c] (5)	3.5 [c] (5)	4.6 (5)	3.44 (30)
3	1.4 (5)	3.2 (5)	1.1 (5)	2.6 (5)	1.6 (5)	3.6 (5)	2.24 (30)
Overall Mean	2.13 (15)	2.95 (15)	2.31 (15)	3.14 (15)	2.75 (15)	3.83 (15)	
	2.54 (30)		2.72 (30)		3.29 (30)		2.85 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 57. MEAN TURBIDITY CONCENTRATION (FORMAZIN TURBIDITY UNITS) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	3.0[b] (5)	2.1 (5)	4.3[b] (5)	2.5 (5)	4.2[b] (5)	4.0 (5)	3.37 (30)
2	1.8[c] (5)	1.4 (5)	2.1[c] (5)	1.9 (5)	2.3[c] (5)	2.9 (5)	2.09 (30)
3	9.7 (5)	2.0 (5)	18.4 (5)	2.4 (5)	22.6 (5)	2.7 (5)	9.63 (30)
Over-all Mean	4.87 (15)	1.86 (15)	8.27 (15)	2.25 (15)	9.73 (15)	3.19 (15)	
	3.37 (30)		5.26 (30)		6.46 (30)		5.03 (90)

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 58. MEAN CONDUCTIVITY CONCENTRATION (MICROMHOS/CENTIMETER) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	300.0 [a] (5)	260.0 [a,b] (5)	300.0 (5)	280.0 [a] (5)	308.0 [a] (5)	287.0 [a] (5)	289.17 (30)
2	337.0 (5)	323.8 [c] (5)	321.0 (5)	327.8 (5)	344.0 (5)	323.2 (5)	329.47 (30)
3	323.8 (5)	292.6 (5)	323.0 (5)	304.8 (5)	329.4 (5)	309.6 (5)	313.87 (30)
Overall Mean	320.27 (15)	292.13 (15)	314.67 (15)	304.20 (15)	327.13 (15)	306.60 (15)	
	306.20 (30)		309.43 (30)		316.87 (30)		310.83 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 59. MEAN SUSPENDED SOLIDS CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLES SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	29.8[a] (5)	15.2 (5)	20.8[b] (5)	8.2 (5)	32.8[b] (5)	18.0 (5)	20.80 (30)
2	4.8 (5)	10.4 (5)	6.4[c] (5)	8.4 (5)	11.2[c] (5)	16.2 (5)	9.57 (30)
3	23.6 (5)	12.6 (5)	52.0 (5)	16.6 (5)	84.2 (5)	14.6 (5)	33.93 (30)
Over-all Mean	19.40 (15)	12.73 (15)	26.40 (15)	11.07 (15)	42.73 (15)	16.27 (15)	
	16.07 (30)		18.73 (30)		29.50 (30)		21.43 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 60. MEAN TOTAL SOLIDS CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR EDGEWATER BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	196.4[b] (5)	202.2 (5)	194.4[b] (5)	219.6[b] (5)	191.4[b] (5)	241.6[b] (5)	207.60 (30)
2	228.4 (5)	201.6 (5)	224.8 (5)	187.6 (5)	209.8[c] (5)	196.6 (5)	208.13 (30)
3	262.6 (5)	163.4 (5)	257.4 (5)	163.2 (5)	291.2 (5)	159.2 (5)	216.17 (30)
Over-all Mean	229.13 (15)	189.07 (15)	225.53 (15)	190.13 (15)	230.80 (15)	199.13 (15)	
	209.10 (30)		207.83 (30)		214.97 (30)		210.63 (90)

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 61. MEAN TOTAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	79 (5)	33 (5)	204 (5)	125 (5)	3,720[a,b] (5)	149 (5)	718 (30)
2	724 (5)	726 (5)	544 (5)	257 (5)	282 (5)	473 (3)	503 (28)
3	378 (5)	123 (5)	192 (5)	138 (5)	150 (5)	1,062 (5)	341 (30)
Over-all Mean	394 (15)	294 (15)	313 (15)	173 (15)	1,384 (15)	575 (13)	521 (88)
	344 (30)		243 (30)		1,008 (28)		

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 62. MEAN TOTAL FECAL COLIFORM CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	46 (5)	2 (5)	38 (5)	14 (5)	56 (5)	110 (5)	44 (30)
2	25 (5)	622 (5)	24 (5)	96 (5)	28 (5)	58 (5)	142 (30)
3	82 (5)	34 (5)	25 (5)	30 (5)	35 (5)	264 (5)	78 (30)
Over-all Mean	51 (15)	219 (15)	29 (15)	46 (15)	40 (15)	144 (15)	
	135 (30)		38 (30)		92 (30)		88 (90)

TABLE 63. MEAN TOTAL ESCHERICHIA COLI CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	39 (5)	2 (5)	36 (5)	14 (5)	54 (5)	69 (5)	36 (30)
2	24 (5)	620 (5)	19 (5)	93 (5)	27 (5)	55 (5)	139 (30)
3	74 (5)	8 (5)	21 (5)	21 (5)	31 (5)	216 (5)	62 (30)
Over-all Mean	46 (15)	210 (15)	25 (15)	42 (15)	37 (15)	113 (15)	
	128 (30)		34 (30)		75 (30)		79 (90)

TABLE 64. MEAN TOTAL FECAL STREPTOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	55 (5)	8 (5)	26 (5)	54 (5)	35 (5)	135 (5)	52 (30)
2	12 (5)	21 (5)	1 (5)	37 (5)	11 (5)	115 (5)	33 (30)
3	55 (5)	14 (5)	16 (5)	39 (5)	18 (5)	172 (5)	52 (30)
Over-all Mean	41 (15)	14 (15)	14 (15)	43 (15)	21 (15)	141 (15)	
	27 (30)		29 (30)		81 (30)		46 (90)

TABLE 65. MEAN TOTAL PSEUDOMONAS AERUGINOSA CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	2 (5)	1 (5)	8 (5)	11 (5)	23 (5)	16 (5)	10 (30)
2	4 (5)	3 (5)	2 (5)	8 (5)	14 (5)	18 (5)	8 (30)
3	4 (5)	1 (5)	4 (5)	1 (5)	55 (5)	2 (5)	11 (30)
Over-all Mean	3 (15)	2 (15)	5 (15)	7 (15)	30 (15)	12 (15)	
	3 (30)		6 (30)		21 (30)		10 (90)

TABLE 66. MEAN TOTAL STAPHYLOCOCCUS CONCENTRATION (NUMBER/100 ml. SAMPLE) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	812 (5)	--	1,028 (5)	--	1,996[a,b] (5)	--	1,279 (15)
2	982 (5)	430 (5)	648 (5)	546[c] (5)	774 (5)	642 (5)	670 (30)
3	488 (5)	444 (5)	562 (5)	2,026 (5)	744 (5)	916 (5)	863 (30)
Over-all Mean	761 (15)	437 (10)	746 (15)	1,286 (10)	1,171 (15)	779 (10)	
	631 (25)		962 (25)		1,014 (25)		869 (75)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 67. MEAN pH CONCENTRATION BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	8.5 [a] (5)	8.6 [a] (5)	8.5 (5)	8.6 [a] (5)	8.6 (5)	8.7 (5)	8.60 (30)
2	8.4 [c] (5)	8.7 [c] (5)	8.5 (5)	8.7 [c] (5)	8.6 (5)	8.7 (5)	8.59 (30)
3	8.5 (5)	8.6 (5)	8.5 (5)	8.6 (5)	8.6 (5)	8.7 (5)	8.57 (30)
Overall Mean	8.46 (15)	8.61 (15)	8.50 (15)	8.64 (15)	8.60 (15)	8.70 (15)	
	8.53 (30)		8.58 (30)		8.64 (30)		8.59 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3

TABLE 68. MEAN CHLORIDE CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	21.6 ^{a,b} (5)	21.2 ^{a,b} (5)	21.8 ^{a,b} (5)	20.8 ^{a,b} (5)	22.0 ^{a,b} (5)	20.2 ^{a,b} (5)	21.27 (30)
2	38.8 ^{c} (5)	29.6 ^{c} (5)	38.8 ^{c} (5)	29.8 ^{c} (5)	37.2 ^{c} (5)	27.4 (5)	33.60 (30)
3	31.2 (5)	26.0 (5)	32.0 (5)	25.2 (5)	29.8 (5)	25.0 (5)	28.20 (30)
Over-all Mean	30.53 (15)	25.60 (15)	30.87 (15)	25.27 (15)	29.67 (15)	24.20 (15)	
	28.07 (30)		28.07 (30)		26.93 (30)		27.69 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 69. MEAN BOD_5 CONCENTRATION (mg/1) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	4.0 [a,b] (5)	1.8 (5)	4.6 [a,b] (5)	2.7 (5)	3.8 [a,b] (5)	2.4 (5)	3.11 (30)
2	2.1 [c] (5)	2.5 [c] (5)	2.1 (5)	3.1 [c] (5)	2.7 [c] (5)	3.1 (5)	2.61 (30)
3	1.0 (5)	1.4 (5)	1.4 (5)	2.2 (5)	1.9 (5)	2.5 (5)	1.72 (30)
Overall Mean	2.33 (15)	1.89 (15)	2.51 (15)	2.69 (15)	2.81 (15)	2.65 (15)	
	2.11 (30)		2.60 (30)		2.73 (30)		2.48 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 70. MEAN TURBIDITY CONCENTRATION (FORMAZIN TURBIDITY UNITS) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	6.8 [a,b] (5)	2.3 (5)	10.0 [a,b] (5)	4.2 [b] (5)	9.0 [a,b] (5)	6.8 [a,b] (5)	6.52 (30)
2	4.1 (5)	3.4 [c] (5)	4.1 (5)	6.2 [c] (5)	4.6 (5)	10.6 [c] (5)	5.49 (30
3	4.7 (5)	1.3 (5)	4.8 (5)	1.9 (5)	5.0 (5)	2.5 (5)	3.35 (5)
Over-all Mean	5.21 (15)	2.32 (15)	6.29 (15)	4.09 (15)	6.21 (15)	6.60 (15)	
	3.76 (30)		5.19 (30)		6.40 (30)		5.12 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 71. MEAN CONDUCTIVITY CONCENTRATION (MICROMHOS/CENTIMETER) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	314.0 (5)	257.0 [a,b] (5)	311.0 [a] (5)	294.0 [a] (5)	308.0 [a] (5)	302.0 (5)	297.67 (30)
2	294.0 (5)	321.0 [c] (5)	345.0 [c] (5)	328.6 [c] (5)	340.0 [c] (5)	321.2 [c] (5)	324.97 (30)
3	301.4 (5)	294.6 (5)	309.6 (5)	273.0 (5)	315.6 (5)	290.6 (5)	297.47 (30)
Over-all Mean	303.13 (15)	290.87 (15)	321.87 (15)	298.53 (15)	321.20 (15)	304.60 (15)	
	297.00 (30)		310.20 (30)		312.90 (30)		306.70 (30)

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[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 72. MEAN SUSPENDED SOLIDS CONCENTRATION (mg/1) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	36.8 [a,b] (5)	9.4 (5)	58.0 [a,b] (5)	11.6 [a] (5)	35.8 [a,b] (5)	23.6 (5)	29.20 (30)
2	10.6 (5)	10.8 (5)	9.6 (5)	24.8 [c] (5)	15.8 (5)	31.6 (5)	17.20 (30)
3	10.8 (5)	3.2 (5)	17.4 (5)	13.6 (5)	20.8 (5)	29.6 (5)	15.90 (30)
Overall Mean	19.40 (15)	7.80 (15)	28.33 (15)	16.67 (15)	24.13 (15)	28.27 (15)	
	13.60 (30)		22.50 (30)		26.20 (30)		20.77 (30)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

TABLE 73. MEAN TOTAL SOLIDS CONCENTRATION (mg/l) BY WEEKEND AND TIME OF DAY FOR HEADLANDS BEACH WITH SAMPLE SIZE GIVEN IN PARENTHESES

	Time of Day						
	0900		1200		1500		Overall Mean
Weekend \ Day	Saturday	Sunday	Saturday	Sunday	Saturday	Sunday	
1	201.4 [a,b] (5)	220.2 [b] (5)	215.8 (5)	211.8 [a,b] (5)	224.0 (5)	234.6 [a,b] (5)	217.97 (30)
2	221.0 (5)	204.6 [c] (5)	228.8 [c] (5)	190.6 [c] (5)	216.6 [c] (5)	207.2 [c] (5)	211.47 (30)
3	223.6 (5)	152.2 (5)	209.8 (5)	166.8 (5)	236.2 (5)	157.2 (5)	190.97 (30)
Overall Mean	215.33 (15)	192.33 (15)	218.13 (15)	189.73 (15)	225.60 (15)	199.67 (15)	
	203.83 (30)		203.93 (30)		212.63 (30)		206.80 (90)

[a] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 2.

[b] Mean for weekend 1 is significantly different ($p<0.05$) from the mean for weekend 3.

[c] Mean for weekend 2 is significantly different ($p<0.05$) from the mean for weekend 3.

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TABLE 74. MEAN CONCENTRATION OF MICROBIOLOGICAL, PHYSICAL AND CHEMICAL VARIABLES FOR WATER SAMPLES FROM EDGEWATER BEACH TAKEN AT CENTER CHEST DEPTH, 1200 HOURS, MONDAY THROUGH FRIDAY, WITH SAMPLE SIZE GIVEN IN PARENTHESES

Variable	Mon.	Tues.	Wed.	Thur.	Fri.	Overall Mean
Total Coliform (#/100 ml. sample)	40000 (1)	41650 (2)	16545 (2)	20500 (2)	15900 (2)	25466 (9)
Fecal Coliform (#/100 ml. sample)	440 (1)	33055 (2)	3005 (2)	1238 (2)	1890 (2)	8757 (9)
Escherichia coli (#/100 ml. sample)	420 (1)	3255 (2)	2905 (2)	1233 (2)	1840 (2)	2098 (9)
Fecal Streptoccoccus (#/100 ml. sample)	370 (1)	16543 (2)	602 (2)	225 (2)	204 (2)	3953 (9)
Pseudomonas aeruginosa (#/100 ml. sample)	110 (1)	2320 (2)	181 (2)	71 (2)	32 (2)	592 (9)
Staphlococcus (Total) ((#/100 ml. sample)	1800 (1)	40230 (2)	4565 (2)	2150 (2)	2550 (2)	11199 (9)
pH	8.1 (1)	8.0 (2)	8.5 (2)	8.2 (2)	8.2 (2)	8.21 (9)
Chlorides (mg/1)	26.0 (1)	33.0 (2)	41.0 (2)	30.5 (2)	33.5 (2)	33.56 (9)
BOD_5 (mg/1)	5.9 (1)	3.1 (2)	5.4 (2)	3.0 (2)	2.6 (2)	3.79 (9)
Turbidity (FTU)	4.0 (1)	13.0 (2)	3.6 (2)	3.8 (2)	2.9 (2)	5.62 (9)
Spec. Conductivity (Micromhos/cm	286.0 (1)	321.5 (2)	312.5 (2)	343.0 (2)	344.5 (2)	325.44 (9)
Suspended Solids (gm/1)	61 (1)	72.5 (2)	15.5 (2)	13.0 (2)	12.5 (2)	32.00 (9)
Total Solids (mg/1)	233.0 (1)	288.5 (2)	219.5 (2)	236.0 (2)	247.0 (2)	246.11 (9)

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TABLE 75. MEAN CONCENTRATION OF MICROBIOLOGICAL, PHYSICAL AND CHEMICAL VARIABLES FOR WATER SAMPLES FROM HEADLANDS BEACH TAKEN AT CENTER CHEST DEPTH, 1200 HOURS, MONDAY THROUGH FRIDAY, WITH SAMPLE SIZE GIVEN IN PARENTHESES

Variable	Mon.	Tues.	Wed.	Thur.	Fri.	Overall Mean
Total Coliform (#/100 ml. sample)	1700 (1)	900 (1)	1135 (2)	240 (2)	905 (2)	895 (8)
Fecal Coliform (#/100 ml. sample)	140 (1)	42 (1)	86 (2)	60 (2)	53 (2)	73 (8)
Escherichia coli (#/100 ml. sample)	130 (1)	40 (1)	76 (2)	52 (2)	44 (2)	64 (8)
Fecal Streptoccoccus (#/100 ml. sample)	160 (1)	8 (1)	36 (2)	22 (2)	35 (2)	44 (8)
Pseudomonas aeruginosa (#/100 ml. sample)	40 (1)	8 (1)	31 (2)	19 (2)	14 (2)	22 (8)
Staphlococcus (Total) (#/100 ml. sample)	520 (1)	440 (1)	1130 (2)	1050 (2)	1095 (2)	939 (8)
pH	8.2 (1)	8.3 (1)	8.4 (2)	8.2 (2)	8.2 (2)	8.21 (8)
Chlorides (mg/1)	30.0 (1)	33.0 (1)	48.0 (2)	31.0 (2)	37.5 (2)	37.00 (8)
BOD_5 (mg/1)	2.5 (1)	2.1 (1)	2.5 (2)	1.3 (2)	3.8 (2)	2.48 (8)
Turbidity (FTU)	18.0 (1)	15.0 (1)	4.3 (2)	7.5 (2)	6.6 (2)	8.73 (8)
Spec. Conductivity (Micromhos/cm	316.0 (1)	325.0 (1)	322.0 (2)	330.0 (2)	306.0 (2)	319.63 (8)
Suspended Solids (mg/1)	68.0 (1)	49.0 (1)	23.0 (2)	27.0 (2)	19.5 (2)	32.00 (8)
Total Solids (mg/1)	273.0 (1)	240.0 (1)	220.0 (2)	225.5 (2)	213.0 (2)	228.75 (8)

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The meteorological variables during the days that water samples were collected are given in Table 76. A compass (Figure 1) is included so that the wind direction in degrees can be transcribed to a north, south, east or west direction. In addition, Table 76 includes the water temperature and wave height for both beaches. The following is noted in Table 76: (1) Wind direction was inconsistent during the study period; (2) Wind speed varied from 2 to 25 knots; (3) Precipitation was little; (4) Air temperature varied from 21.0 to 31.9°C; (5) Water temperature at the two beaches was quite similar with a low of 19.9°C; and a high of 28.0°C; and (6) Wave height was similar at the two beaches with a minimum of 0.09 meters and a maximum of 1.42 meters.

Although no statistical tests were run to determine whether meteorological data relates to water quality data, visual inspection of the observed data generally shows no trend. For instance, one might hypothesize that the microbiological concentrations would be higher when it is raining. From Table 76 it can be seen that it rained on weekend one, but not on weekends two or three. However, inspection of the microbiological data at Edgewater Beach generally shows higher microbial concentrations on weekend three when compared to weekend one (Tables 48-53). The one exception was for total staphylococcus concentration which was higher on weekend one when compared to weekend three.

In summary, the mean concentration for most of the water measurements for Saturday and Sunday generally were found to be significantly different ($p<0.05$) for both beaches (Tables 22-47). Significant differences for these water variable concentrations were most prevalent between 0900 and 1500 hours at both beaches. On the whole, there were no differences noted between the five collection locations at each beach. When weekends were compared by day and time of day many significant differences ($p<0.05$) were found for the microbiological, physical and chemical variables (Tables 48-73).

It is concluded from the above summary that one needs to know the specific time of day and day of weekend that an individual was exposed in order to relate the health effects of recreational water to some water quality variable. In addition, the major differences observed between Edgewater and Headlands Beaches were found in the microbiological variables, while the physical and chemical variables were observed to be quite similar. As a consequence, it is concluded that only microbiological variables need to be investigated for a subsequent study.

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TABLE 76. METEOROLOGICAL AND PHYSICAL VARIABLES OF EDGEWATER AND HEADLANDS BEACHES

Date 1977	Time	Wind Direction (Degrees)	Wind Speed (Knots)	Precip. For day (cm.)	Air Temp. ^oC	Edgewater Water Temp. ^oC	Headlands Water Temp. ^oC	Edgewater Wave Ht. (Meters)	Headlands Wave Ht. (Meters)
7/16	0900	340	9	0.254	26.1	26.7	24.9	0.91	0.76
	1200	50	5		28.4	26.4	27.2	0.91	0.76
	1500	100	2		28.6	26.6	27.8	0.46	0.76
7/17	0900	270	9	0.508	26.1	26.3	27.8	0.15	0.46
	1200	260	2		30.3	25.9	27.8	0.30	0.61
	1500	340	9		26.3	27.4	27.8	0.76	1.22
7/18	1200	70	2	0.254	31.9	--	--	1.42	--
7/19	1200	190	7	2.540	26.9	26.0	--	1.07	--
7/20	1200	270	11	0.0	28.9	28.0	27.5	0.76	1.07
7/21	1200	320	15	0.0	27.6	28.0	27.1	0.76	0.76
7/22	1200	60	13	0.0	22.1	27.0	26.5	0.46	0.76
7/23	0900	110	2	0.0	24.3	23.4	26.6	0.15	0.15
	1200	350	5		25.4	25.2	27.1	0.15	0.15
	1500	340	8		25.3	26.9	27.7	0.15	0.15
7/24	0900	250	13	0.0	25.7	19.9	--	0.09	0.09
	1200	300	8		27.4	25.9	26.7	0.46	0.46
	1500	340	7		27.8	27.7	26.3	0.46	0.76
7/25	1200	20	19	0.0	24.5	26.7	26.7	0.76	0.76
7/26	1200	350	9	0.0	21.0	26.1	26.1	1.07	1.07
7/27	1200	60	8	0.0	21.9	26.7	26.4	0.15	0.15
7/28	1200	60	9	0.0	23.7	27.0	25.3	0.46	0.46
7/29	1200	210	10	3.302	27.1	26.4	25.0	0.46	0.46
7/30	0900	350	5	0.0	25.1	22.9	24.4	0.46	0.76
	1200	10	3		26.1	24.7	25.4	0.46	0.46
	1500	340	9		24.8	27.0	26.4	0.46	0.46
7/31	0900	210	19	0.0	27.2	24.0	25.7	0.09	0.46
	1200	230	25		28.8	24.0	26.7	0.15	0.76
	1500	240	25		30.3	25.0	27.0	0.15	0.76

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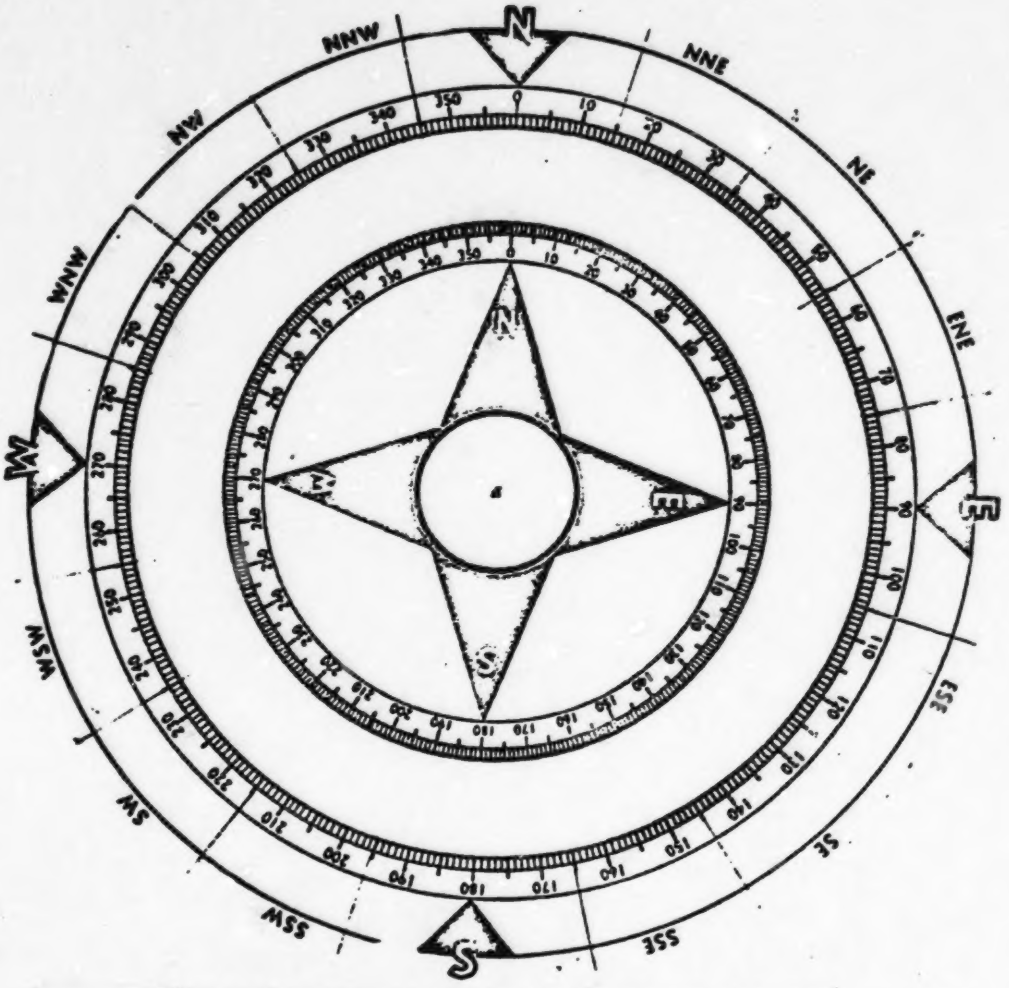
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Figure 1. Compass for determining wind direction.

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APPENDIX A

RECREATIONAL WATER QUALITY AND HEALTH QUESTIONNAIRE

Recruitment

O.M.B. No. 158-R-0154
Approval Expires March 31, 1978

Sequence No: ______________

License No: ______________

Date: ____________________

Time: ______________ **AM, PM**

Interviewer: ______________

I. RECRUITMENT

Hello. My name is ____. I am cooperating with the Cleveland Department of Health and the U.S. Environmental Protection Agency. We are doing a study of swimming conditions at public beaches and need your help to improve swimming and picnic conditions at beaches, if we find that improvements are needed.

First, I want to ask if you are a resident of the Cleveland Metropolitan area?

(If YES, continue) (If NO, thank them and goodbye)

Is it a toll charge for you to call Cleveland from your home?

(If NO, continue) (If YES, thank them and say goodbye)

What we are asking you to do is tell us about your swimming experience and your health when we telephone you. Examples of some of the questions we will ask are: "How long were you in the water?"; "Did you get your head wet?"; and "Have you had a cold in the last week?" We will call tonight, or tomorrow, and once each week for 3 weeks after this short interview. I only need a moment now to ask a few questions about you and your family, so I may contact you later.

(Don't Read) Assurance of Confidentiality: **All information that would permit identification of individuals will be held in strict confidence, will be used only by persons engaged in and for the purpose of the survey and will not be disclosed or released to others for any purpose. The results will be used only when combined with those of many other people.**

I (Respondent) Name	II	III	IV	V	VI
________	________	________	________	________	________
________	________	________	________	________	________
Rel.________	Rel.________	Rel.________	Rel.________	Rel.________	Rel.________
Age ________	Age ________	Age ________	Age ________	Age ________	Age ________
Male........1	Male........1	Male........1	Male........1	Male........1	Male........1
Female......2	Female......2	Female......2	Female......2	Female......2	Female......2
White.......1	White.......1	White.......1	White.......1	White.......1	White.......1
Black.......2	Black.......2	Black.......2	Black.......2	Black.......2	Black.......2
Other.......3	Other.......3	Other.......3	Other.......3	Other.......3	Other.......3

Phone: Home
Work
Friend's ____________________

______________________________ AM/PM

____
(Number)

____
City State Zip

First follow-up phone call

(same day or day after recruitment)

Sequence No.:____________________

Resp. Name:____________________

Tel. No.: (   )________________

License No.:____________________

Interviewer:____________________

First Attempt: Date: Time:__________ Code:____

Second Attempt: Date: Time:__________ Code:____

Third Attempt: Date: Time:__________ Code:____

Codes:
1 Completed Call
2 Appt.____________________
3 Eligible Respondent not in
4 No. Ans.
5 Line Busy
6 Wrong No.
7 Refusal
8 Other____________________
(Specify)

Questionnaire I : Interviewer's name ______________________________
Recruitment:
Day____________________, Date________________ and Time__________

... 1 ... 2	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8
yes/1 no/2 ___	yes/1 no/2 ___	yes/1 no/2 ___	yes/1 no/2 ___	yes/1 no/2 ___	yes/1 no/2 ___
___ min/hr ... 998	___ min/hr 998	___ min/hr 998	___ min/hr 998	___ min/hr 998	___ min/hr 998
... 1 ... 2 ...	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8
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... 1 ... 2 ... 3 ...	1 2 3 8	1 2 3 8	1 2 3 8	1 2 3 8	1 2 3 8
___ hrs.	___ hrs.	___ hrs.	___ hrs.	___ hrs.	___ hrs.

Hello. My name is ________________________________.

I/ _________________________________ spoke with
(recruiter's name)
you (today/yesterday) at the beach and would now like to ask you a few questions about your household's swimming experience (today/yesterday).

(Ask these questions first for respondent only.)

A. 1. Did (you/_____________) go in the water at all (today/yesterday)?

(1) Yes ***(go to Q. 3)*****..............................**

(2) No ***(go to Q. 2)*****..............................**

(8) Don't Know ***(Record for other household members only.)*****....................**
(repeat A. 1 for other household members, when done go to Q. 6)

2. Do you normally go swimming?...............

(If yes,) **Why didn't you go swimming?...................................**
(repeat A. 1 for other household members, when done go to Q. 6)

3. About how long (were you/was ____________) in the water that day?........

Don't Know...................................

4a. Did (you/ ________) get (your/his/her) entire body wet - including (your/his/her) face and head?

(1) Yes ***(go to Q. 4b)*****.............................**

(2) No ***(go to Q. 5)*****..............................**

(Record for other household members only)
(3) Don't Know ***(when done go to Q. 6)*****............**

4b. About how long was (your/his/her) entire body - including face and head - wet?

Don't Know..................................

(repeat A. 1 for other household members, when done go to Q. 6)

5. Did (you/_________) go in up to (your/his/her)...........

(1) Shoulders?...................................

(2) Waist?.......................................

(3) Knees?.......................................

(Record for other household members only)
(8) Don't Know...................................

(Repeat A 1 thru 5 for each household member who was at beach.)

6. About how long was your family at the beach (today/yesterday)?

(Ask B first for respondent, then repeat for other household members.)

B. 1. (Have you/has ______________) gone swimming any other time during the last week other than (today/yesterday) at (Headlands/Edgewater) Park?

(1) Yes...
(Ask 2 thru 4, then repeat 1 for others)

(2) No..
(Ask 5 if not respondent, then repeat 1 for remaining household members)

(8) Don't Know..
(Repeat 1 for remaining household members)

2. How many days (were you/was______________) swimming last week?.............

3. Where did (you/ ______________) go swimming last week?..............

Was it at:

(Read list, circle all that apply)

(1/2) (1. Edgewater/2. Headlands..........................

(3) Another beach on Lake Erie..........................

(4) Any other lake or river.............................

(5) A public pool.......................................

(6) Some other place....................................

(8) *(Don't read)* Don't Know...........................

4. *(Do not ask No. 4 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Did you see ________________ swimming or................
(name)

Did ______________ tell you (he/she) went swimming.............

(Repeat 1 for others) Other...

5. *(Do not ask No. 5 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Were you with ______________ and know that (he/she) did not go swimming?
(name)

(1) yes......................

(2) no.......................

(3) other (specify)..........

(Repeat 1 for others)

C. *DO NOT ASK, BUT IF POSSIBLE, RECORD THE FOLLOWING INFORMATION.*

Did the respondent confer with this household member to obtain answers? (1)yes ....
(2)no.........

Comments:

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 8	8	8	8	8	8
___ days	___ days	___ days	___ days	___ days	___ days
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 8	8	8	8	8	8
...	1	1	1	1	1
...	2	2	2	2	2
...	3	3	3	3	3
	1	1	1	1	1
	2	2	2	2	2
	3	3	3	3	3
	1	1	1	1	1
	2	2	2	2	2

(First ask Q. 1 for the respondent only.)

D. 1. In the past week (have you/has __________) been ill? That is, have you had any of the following conditions:
(If yes, circle positive responses, brief explanation in blank)
(If none or don't know, repeat for next household member; if last household member, go to E.)

(Read conditions 1-16)

(1) a cold
(2) a cough
(3) sore throat
(4) stomach ache
(5) nausea
(6) vomiting
(7) intestinal distress
(1) diarrhea
(2) ear ache
(3) ear infection
(4) skin rash
(5) skin irritation
(6) sunburn
(7) itchy or watery eyes
(1) sty
(2) other (specify)
(3) none
(8) don't know

(If positive response to any of the illnesses, go to 2.)

2. On what day(s) were you ill?

3. *(If on Sat./Sun.)* Did the illness start while at the beach?

4. While ill were (you/he/she) able to do normal activities on those days?

(If no, circle all appropriate; read list.)

(1) Restricted activity?
(2) Stayed in bed?
(3) Stayed home from work/school?
(4) Contacted doctor?
(5) Had temperature over 100 degrees?
(8) *(Don't read)* Don't Know

5. Did (you/he/she) get any treatment including aspirin or other over the counter drugs?
(If yes,) What was it?
(Repeat D for other household members; if last household member, go to E.)

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 8	8	8	8	8	8
S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7
yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2
yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 8	8	8	8	8	8
yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______

E. I would like to call you again next ____________ and find out about
(day of week)

you and your household's swimming experience and health in the coming week. Would this be a convenient time to call next week? If not, when would be best for you?

AM
PM ____________________________

THANK YOU VERY MUCH.

Second follow-up phone call

(7 or 8 days after initial contact)

Sequence No.: ______________________

Resp. Name: ______________________

Tel. No.: ( ) ______________________

License No.: ______________________

Interviewer: ______________________

First Attempt: Date:______ Time:______ Code______

Second Attempt: Date:______ Time:______ Code______

Third Attempt: Date:______ Time:______ Code______

Codes:
1. Completed Call
2. Appt. ______________________
3. Eligible Respondent not in
4. No Answer
5. Line Busy
6. Wrong No.
7. Refusal
8. Other ______________________ (specify)

Questionnaire I: Interviewer's Name ______________________

Day ____________, Date ____________, Time ____________

Questionnaire II: Interviewer's Name ______________________

Day ____________, Date ____________, Time ____________

Hello, this is ______________. I/ ________________ spoke with you last ______________ (day of week) and asked some questions regarding our recreational water and health study and I would like now to ask you a few questions about (you/your household's) swimming experience and illnesses since then.

(Ask F first for respondent, then repeat for other household members.)

F. 1. (Have you/has ______________) gone swimming any other time during the last week other than (today/yesterday) at (Headlands/Edgewater) Park?

(1) Yes..
(Ask 2 thru 4, then repeat 1 for others)

(2) No...
(Ask 5 if not respondent, then repeat 1 for remaining household members)

(8) Don't Know...
(Repeat 1 for remaining household members)

2. How many days (were you/was ______________) swimming last week?..............

3. Where did (you/ ______________) go swimming last week?..............

Was it at:

(Read list, circle all that apply)

(1/2) (1. Edgewater/2. Headlands.............................
(3) Another beach on Lake Erie...............................
(4) Any other lake or river..................................
(5) A public pool..
(6) Some other place.....................................
(8) *(Don't read)* Don't Know.............................

4. *(Do not ask No. 4 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Did you see ________________ (name) swimming or................

Did ______________ tell you (he/she) went swimming..............

(Repeat 1 for others) Other..

5. *(Do not ask No. 5 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Were you with ______________ (name) and know that (he/she) did not go swimming?

(1) yes.......................
(2) no........................
(3) other (specify)..........

(Repeat 1 for others)

G. *DO NOT ASK, BUT IF POSSIBLE, RECORD THE FOLLOWING INFORMATION.*

Did the respondent confer with this household member to obtain answers? (1)yes ....
(2)no.........

Comments:

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 8	8	8	8	8	8
___ days	___ days	___ days	___ days	___ days	___ days
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 8	8	8	8	8	8
...	1	1	1	1	1
...	2	2	2	2	2
...	3	3	3	3	3
	1	1	1	1	1
	2	2	2	2	2
	3	3	3	3	3
	1 2	1 2	1 2	1 2	1 2

(First ask Q. 1 for the respondent only.)

H. 1. In the past week (have you/has __________) been ill? That is, have you had any of the following conditions:
(If yes, circle positive responses, brief explanation in blank)
(If none or don't know, repeat for next household member; if last household member, go to I.)

(Read conditions 1-16)

(1) a cold.....................................
(2) a cough....................................
(3) sore throat................................
(4) stomach ache...............................
(5) nausea.....................................
(6) vomiting...................................
(7) intestinal distress........................
(1) diarrhea...................................
(2) ear ache...................................
(3) ear infection..............................
(4) skin rash..................................
(5) skin irritation............................
(6) sunburn....................................
(7) itchy or watery eyes.......................
(1) sty..
(2) other (specify)............................
(3) none.......................................
(8) don't know.................................

(If positive response to any of the illnesses, go to 2.)

2. On what day(s) were you ill?..

4. While ill were (you/he/she) able to do normal activities on those days?........

(If no, circle all appropriate; read list.)

(1) Restricted activity?...........................
(2) Stayed in bed?.................................
(3) Stayed home from work/school?..................
(4) Contacted doctor?..............................
(5) Had temperature over 100 degrees?..............
(8) *(Don't read)* Don't Know.......................

5. Did (you/he/she) get any treatment including aspirin or other over the counter drugs?
(If yes,) What was it?
(Repeat H for other household members; if last household member, go to I.)

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 8	8	8	8	8	8
S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7
yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 8	8	8	8	8	8
yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______

The following questions apply only to the adult head of households or anyone else in the family that significantly contributes to the family income. Could I have the names of these persons please? *(If you don't already know)* How is ______________________ related to you?

(Ask first for respondent, then for respondent's spouse. If respondent is single, indicate that.)

I. What is the highest grade or year of school (you/______________) completed?
(name)

DO NOT READ LIST:

None..

Elementary and Jr. High..........................

High School....................................

College..

Graduate School................................

Graduate or professional degree.................

J. 1. (Are you/is your spouse) currently employed?

(1) Part-time....................................

(2) Full-time....................................

(3) No...

2a. *(If employed,)* what is (your/your spouse's) main occupation or job title?

b. *(If not,)* are (you/is your spouse):

(1) a student..................................

(2) a homemaker................................

(3) retired....................................

(4) temporarily out of work....................

(5) other (specify)............................

K. I would like to call you again next ___________________ and find out about
(day of week)
your and your household's swimming experience this coming week. Would this be a convenient time to call next week? If not, when would be best for you?

THANK YOU VERY MUCH.

name ____________ rel. ____________ ..... Single	name ____________ rel. ____________	name ____________ rel. ____________	name ____________ rel. ____________
..... 00 ..... 01 02 03 04 ..... 05 06 07 08 ..... 09 10 11 12 ..... 13 14 15 16 ..... 17 18	00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18	00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18	00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18
..... 1 ..... 2 3	1 2 3	1 2 3	1 2 3
..... 1 ..... 2 ..... 3 ..... 4 ..... 5 ________	1 2 3 4 5 ________	1 2 3 4 5 ________	1 2 3 4 5 ________

______________ AM
PM

Third follow-up phone call

(2 weeks after initial contact)

Sequence No.: ____________________

Resp. Name: ____________________

Tel. No.: (   ) ____________________

License No.: ____________________

Interviewer: ____________________

First Attempt: Date: Time: __________ Code __________

Second Attempt: Date: Time: __________ Code __________

Third Attempt: Date: Time: __________ Code __________

Codes:
1. Completed Call
2. Appt. ____________________
3. Eligible Respondent not in
4. No Answer
5. Line Busy
6. No Contact
7. Refusal
8. Other (specify)

Questionnaire I:
Recruitment: Interviewer's name ______________________________

Day ______________, Date ______________, Time ______________

Questionnaire II: Interviewer's name ______________________________

Day ______________, Date ______________, Time ______________

Questionnaire III: Interviewer's name ______________________________

Day ______________, Date ______________, Time ______________

Hello, this is ______________. I/ ________________ spoke with you last ________________ and asked some questions regarding our recreational water
(day of week)
and health study and I would like now to ask you a few questions about (you/your household's) swimming experience and illnesses since then.

(Ask L first for respondent, then repeat for other household members.)

L. 1. (Have you/has ______________) gone swimming any other time during the last week other than (today/yesterday) at (Headlands/Edgewater) Park?

(1) Yes..
(Ask 2 thru 4, then repeat 1 for others)

(2) No..
(Ask 5 if not respondent, then repeat 1 for remaining household members)

(8) Don't Know...
(Repeat 1 for remaining household members)

2. How many days (were you/was ______________) swimming last week?............

3. Where did (you/ ______________) go swimming last week?..............

Was it at:

(Read list, circle all that apply)

(1/2) (1. Edgewater/2. Headlands..........................

(3) Another beach on Lake Erie..........................

(4) Any other lake or river.............................

(5) A public pool.......................................

(6) Some other place...................................

(8) *(Don't read)* Don't Know...............................

4. *(Do not ask No. 4 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Did you see ________________ swimming or...............
(name)

Did ______________ tell you (he/she) went swimming..............

(Repeat 1 for others) **Other..**

5. *(Do not ask No. 5 for respondent.)* For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:

Were you with ________________ and know that (he/she) did not go swimming?
(name)

(1) yes......................

(2) no.......................

(3) other (specify)..........

(Repeat 1 for others)

M. *DO NOT ASK, BUT IF POSSIBLE, RECORD THE FOLLOWING INFORMATION.*

Did the respondent confer with this household member to obtain answers? (1)yes ....
(2)no.........

Comments:

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 8	8	8	8	8	8
___ days	___ days	___ days	___ days	___ days	___ days
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 8	8	8	8	8	8
...	1	1	1	1	1
...	2	2	2	2	2
...	3	3	3	3	3
	1	1	1	1	1
	2	2	2	2	2
	3	3	3	3	3
	1 2	1 2	1 2	1 2	1 2

(First ask Q. 1 for the respondent only.)

N. 1. In the past week (have you/has __________) been ill? That is, have you had any of the following conditions:
(If yes, circle positive responses, brief explanation in blank)
(If none or don't know, repeat for next household member; if last household member, go to O.)

(Read conditions 1-16)

(1) a cold
(2) a cough
(3) sore throat
(4) stomach ache
(5) nausea
(6) vomiting
(7) intestinal distress
(1) diarrhea
(2) ear ache
(3) ear infection
(4) skin rash
(5) skin irritation
(6) sunburn
(7) itchy or watery eyes
(1) sty
(2) other (specify)
(3) none
(8) don't know

(If positive response to any of the illnesses, go to 2.)

2. On what day(s) were you ill?

4. While ill were (you/he/she) able to do normal activities on those days?

(If no, circle all appropriate; read list.)

(1) Restricted activity?
(2) Stayed in bed?
(3) Stayed home from work/school?
(4) Contacted doctor?
(5) Had temperature over 100 degrees?
(8) *(Don't read)* Don't Know

5. Did (you/he/she) get any treatment including aspirin or other over the counter drugs?
(If yes,) What was it?
(Repeat N for other household members; if last household member, go to O.)

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 8	8	8	8	8	8
S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7
yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 8	8	8	8	8	8
yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______

O. Now I would like to ask some questions about more permanent health conditions that you or members of your household may have. I will read a list of diseases to you. Please tell me who has one or more of the following:

(Circle number corresponding to disease.)

1. Chronic skin problems

    (1) Chronic rash
    (2) Severe acne
    (3) Eczema
    (4) Psoriasis
    (5) Other (specify)

2. Chronic respiratory illnesses or conditions such as:

    (1) Sinus irritation, or infection (sinusitis)
    (2) Allergies (Hay Fever)
    (3) Bronchitis
    (4) Emphysema
    (5) Asthma
    (6) Other (specify)

3. Recurring or chronic stomach or abdominal conditions

    (1) Gastric ulcers
    (2) Duodenal ulcers
    (3) Ulcerative colitis
    (4) Spastic colon
    (5) Gall Bladder problems
    (6) Other (specify)

4. In the past 6 months, any of the following conditions:

    (1) Major surgery (specify if stated) ____________________
    (2) Hepatitis (specify type if stated) ____________________
    (3) Infectious Mononucleosis
    (4) Infection of the kidneys, bladder or urinary tract
    (5) Others (specify) ____________________

5. Other chronic conditions

    (01) Anemia (specify if stated) ____________________
    (02) Arthritis (specify if stated) ____________________
    (03) Diabetes (if yes, ask age of onset)
    (04) High blood pressure
    (05) Heart condition (include angina)
    (06) Rheumatic fever
    (07) Stroke
    (08) Cancer (Specify type if given--do not ask) ____________________
    (09) Others (specify) ____________________

...... 1 ...... 2 ...... 3 ...... 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
...... 1 ...... 2 ...... 3 ...... 4 ...... 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
...... 1 ...... 2 ...... 3 ...... 4 ...... 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5 6
...... 1 ...... 2 ...... 3 ...... 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
...... 01 ...... 02 ...... 03 — ...... 04 ...... 05 ...... 06 ...... 07 ...... 08 09	01 02 03 — 04 05 06 07 08 09	01 02 03 — 04 05 06 07 08 09	01 02 03 — 04 05 06 07 08 09	01 02 03 — 04 05 06 07 08 09	01 02 03 — 04 05 06 07 08 09

P. I would like to call you one last time next________________________and find out
(day of week)
about your household's swimming experience this coming week. Would this be a convenient time to call next week? If not, when would be best for you?

____________________________ AM
PM

THANK YOU VERY MUCH

Fourth follow-up phone call

(3 weeks after initial contact)

Sequence No.:______________________________

Resp. Name:______ _______________________

Tel. No.: (   )__________________________

License No.:______________________________

Interviewer:______________________________

First Attempt: Date:
Time:__________Code________

Second Attempt: Date:
Time:__________Code________

Third Attempt: Date:
Time:__________Code________

Codes:
1. Completed Call
2. Appt._______________________
3. Eligible Respondent not in
4. No Answer
5. Line Busy
6. No Contact
7. Refusal
8. Other (specify)

(Questionnaire I)

Recruitment: Interviewer's name____

Day___________________,Date_________________, Time_________________

Questionnaire II: Interviewer's name______________________________________

Day___________________, Date_______________, Time_______________

Questionnaire III: Interviewer's name______________________________________

Day___________________, Date_______________, Time_______________

Questionnaire IV: Interviewer's name______________________________________

Day___________________, Date_______________, Time_______________

Hello, this is ______________. I/ ________________ spoke with you last ________________ and asked some questions regarding our recreational water
(day of week)
and health study and I would like now to ask you a few questions about (you/your household's) swimming experience and illnesses since then.

(Ask Q first for respondent, then repeat for other household members.)

Q. 1. (Have you/has ______________) gone swimming any other time during the last week other than (today/yesterday) at (Headlands/Edgewater) Park?

(1) Yes...
(Ask 2 thru 4, then repeat 1 for others)

(2) No..
(Ask 5 if not respondent, then repeat 1 for remaining household members)

(8) Don't Know..
(Repeat 1 for remaining household members)

2. How many days (were you/was______________) swimming last week?.............

3. Where did (you/ ______________) go swimming last week?..............

Was it at:

(Read list, circle all that apply)

(1/2) (1. Edgewater/2. Headlands..........................

(3) Another beach on Lake Erie...........................

(4) Any other lake or river..............................

(5) A public pool..

(6) Some other place.....................................

(8) *(Don't read)* **Don't Know............................**

4. *(Do not ask No. 4 for respondent.)* **For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:**

Did you see _________________ swimming or................
(name)

Did _______________ tell you (he/she) went swimming............

(Repeat 1 for others) **Other..**

5. *(Do not ask No. 5 for respondent.)* **For the purposes of this study, it is very important that we know how accurate our information is. Therefore, we need to ask the following:**

Were you with ________________ and know that (he/she) did not go swimming?
(name)

(1) yes......................

(2) no.......................

(3) other (specify).........

(Repeat 1 for others)

R. *DO NOT ASK, BUT IF POSSIBLE, RECORD THE FOLLOWING INFORMATION.*

Did the respondent confer with this household member to obtain answers? (1)yes ....

Comments: (2)no.........

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 8	8	8	8	8	8
___ days	___ days	___ days	___ days	___ days	___ days
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 8	8	8	8	8	8
...	1	1	1	1	1
...	2	2	2	2	2
...	3	3	3	3	3
	1	1	1	1	1
	2	2	2	2	2
	3	3	3	3	3
	1 2	1 2	1 2	1 2	1 2

(First ask Q. 1 for the respondent only.)

S. 1: In the past week (have you/has __________) been ill? That is, have you had any of the following conditions:
(If yes, circle positive responses, brief explanation in blank)
(If none or don't know, repeat for next household member; if last household member, go to T.)

(Read conditions 1-16)

(1) a cold..
(2) a cough..
(3) sore throat..
(4) stomach ache..
(5) nausea..
(6) vomiting..
(7) intestinal distress..
(1) diarrhea..
(2) ear ache..
(3) ear infection..
(4) skin rash..
(5) skin irritation..
(6) sunburn..
(7) itchy or watery eyes..
(1) sty..
(2) other (specify)..
(3) none..
(8) don't know..

(If positive response to any of the illnesses, go to 2.)

2. On what day(s) were you ill?..

4. While ill were (you/he/she) able to do normal activities on those days?........

(If no, circle all appropriate; read list.)

(1) Restricted activity?..
(2) Stayed in bed?..
(3) Stayed home from work/school?..
(4) Contacted doctor?..
(5) Had temperature over 100 degrees?..
(8) *(Don't read)* Don't Know..

5. Did (you/he/she) get any treatment including aspirin or other over the counter drugs?
(If yes,) What was it?
(Repeat S for other household members; if last household member, go to T.)

... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 6	6	6	6	6	6
... 7	7	7	7	7	7
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 8	8	8	8	8	8
S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7	S/1 M/2 T/3 W/4 T/5 F/6 S/7
______					
yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2	yes/1 no/2
... 1	1	1	1	1	1
... 2	2	2	2	2	2
... 3	3	3	3	3	3
... 4	4	4	4	4	4
... 5	5	5	5	5	5
... 8	8	8	8	8	8
yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______	yes/1 no/2 ______

(Respondent)	(Respondent's Spouse)				
Name	**Name**	**Name**	**Name**	**Name**	**Name**
________	________	________	________	________	________
________	________	________	________	________	________
Rel.______	Rel.______	Rel.______	Rel.______	Rel.______	Rel.______
Age______	Age______	Age______	Age______	Age______	Age______

T. Thank you very much for participating in this study. Your cooperation is very much appreciated. Goodbye.

APPENDIX B

PROMOTIONAL LETTER

RECREATIONAL WATER QUALITY AND HEALTH

YOUR FAMILY HAS BEEN ASKED TO PARTICIPATE IN A RECREATIONAL WATER QUALITY AND HEALTH SURVEY. THIS STUDY IS BEING DONE IN COOPERATION WITH THE CLEVELAND DEPARTMENT OF HEALTH AND THE U.S. ENVIRONMENTAL PROTECTION AGENCY. WE NEED YOUR HELP TO DETERMINE IF SWIMMING AND PICNIC CONDITIONS NEED IMPROVING. WHAT WE ARE ASKING YOU TO DO IS TELL UP ABOUT YOUR SWIMMING EXPERIENCE AND YOUR HEALTH WHEN WE TELEPHONE YOU. EXAMPLES OF SOME OF THE QUESTIONS WE WILL ASK ARE: "HOW LONG WERE YOU IN THE WATER?"; "DID YOU GET YOUR HEAD WET?"; AND "HAVE YOU HAD A COLD IN THE LAST WEEK?" WE WILL CALL TODAY OR TOMORROW AND ONCE A WEEK FOR THE NEXT THREE WEEKS. WE WILL MAKE EACH PHONE CALL AS SHORT AS POSSIBLE. YOUR HELP IS VERY MUCH APPRECIATED.

THANK YOU.